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UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

WATER-SUPPLY PAPER 341

UNDERGROUND WATERS OF THE COASTAL PLAIN OF GEORGIA

BY

L. W. STEPHENSON AND J. O. VEATCH

AND A DISCUSSION OF

THE QUALITY OF THE WATERS

BY

R. B. DOLE

Prepared in cooperation with the Geological Survey of Georgia

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UNDERGROUND WATER RESOURCES OF THE COASTAL PLAIN OF GEORGIA.

By L. W. Stephenson and J. O. Veatch.

INTRODUCTION.

This report embodies the results of studies of the geology and underground-water resources of the Coastal Plain of Georgia made in accordance with an agreement entered into in 1908 between the Geological Survey of Georgia and the United States Geological Survey. The object of the investigations was to determine so far as possible with the appropriations available the composition, structure, and stratigraphic relations of the deposits of the Coastal Plain and the geologic position, quality, quantity, and economic adaptability of the waters they contain.

S. W. McCallie, State geologist, assigned J. O. Veatch, assistant State geologist, to conduct the investigations on the part of the State Survey, and T. Wayland Vaughan, of the United States Geological Survey, assigned L. W. Stephenson to carry on the work for the Federal Survey. It was also arranged that R. B. Dole, chemist, United States Geological Survey, should discuss the chemistry of the underground waters with especial reference to their economic value.

According to the agreement with the State Survey the results of the investigations were to be published in two volumes, one treating of the geology of the area, to be issued by the State Survey, and the other treating of the underground-water resources, to be issued by the Federal Survey. The former was published in 1912 as Bulletin 26 of the Geological Survey of Georgia. It was originally intended that Mr. Veatch should be the senior author of the present report, but owing to his resignation from the State Survey before the manuscript was completed the larger part of the work was done by Mr. Stephenson, who therefore becomes the senior author.

The data upon which the present volume is based were collected in part during the progress of the field studies, in part by correspondence with postmasters, municipal authorities, well and spring owners, and well drillers, and in part by laboratory studies which consisted chiefly in making analyses of underground waters. Most of the analyses were performed by Edgar Everhart, State chemist of Georgia.

In the preparation of the report Stephenson gave his attention especially to the underground waters contained in the Cretaceous deposits, which outcrop in a relatively small area in the northern and northwestern parts of the Coastal Plain, and Veatch gave his attention to the Tertiary and Quaternary deposits, which outcrop over much the greater portion of the area. The two reports were combined by Stephenson, who incorporated with them an appreciable amount of new data subsequently obtained by correspondence.

The report is necessarily largely a compilation of data collected from many sources. The account of the physiography and geology of the area is mainly that given in Bulletin 26 of the State Survey, slightly modified by later information. The account of the water resources includes, in addition to the data obtained during the progress of the investigations, all the more important available published information, particularly that contained in bulletins of the State Survey and chiefly in Bulletin 15, published in 1908, of which S. W. McCallie is the author.

The authors express their thanks to T. W. Vaughan, of the United States Geological Survey, and S. W. McCallie, of the State Survey. The correlation of the fossiliferous marine Tertiary and Quaternary formations and the interpretation of their stratigraphic relations are based largely upon the paleontologic studies of Mr. Vaughan, who also has had active supervision of the field and office work. Prof. McCallie has been persistent in his endeavors to furnish data from all possible sources.

It is manifestly impossible to mention here the names of all those who have contributed to the material used in the report. The authors, however, have endeavored throughout the report to indicate the source of the data presented, and in this way they have acknowledged many individual contributions. Besides making these individual acknowledgments, they desire to express their great appreciation of the public-spirited manner in which many other persons have responded to their requests for information.

PHYSIOGRAPHY.[1]

The major physiographic divisions of Georgia are the Cumberland Plateau, the Appalachian Valley, the Appalachian Mountains, the Piedmont Plateau, and the Coastal Plain.

CUMBERLAND PLATEAU.

The Cumberland Plateau is made up of flat-topped mountain table-lands of Carboniferous strata. It is represented in Georgia by Lookout, Pigeon, and Sand or Raccoon mountains, which o

[1] Reprinted with some modifications and revisions from the description by Mr. Veatch in Geol. Survey Bull. 26, pp. 25–50, 1911.

a small area in Dade and Walker counties, 1,500 to 2,300 feet above sea level. These mountains rise 700 to 1,400 feet above the valleys and are characterized by comparatively flat tops and steep, precipitous sides. They owe their form to the resistant character and synclinal structure of the rocks capping them.

APPALACHIAN VALLEY.

The Appalachian Valley lies between the Cumberland Plateau on the west and the Appalachian Mountains on the east. Considered as a whole it is a valley, but within itself it is a region of parallel ridges and corresponding subordinate valleys. It is 40 to 50 miles wide and extends from the Tennessee line to the southern part of Polk County and across the State line into Alabama. It is limited on the east by an abrupt scarp of semicrystalline schists of the Appalachian Mountain area, the Cartersville fault line. Geologically, it lies within the Paleozoic area and is a region of intensely folded limestones, sandstones, and shales. The ridges run north and south, are generally steepsided, and owe their existence both to their structure and to the resistant character of the rocks composing them. The valleys have been eroded from the softer strata. The ridges are 1,000 to 1,800 feet and the valleys 600 to 900 feet above sea level.

APPALACHIAN MOUNTAINS.

The Appalachian Mountain area comprises mainly the Blue Ridge, but includes lesser mountain groups both to the east and west. It occupies the northeast and north-central parts of the State, including practically all of Rabun, Towns, Union, and Fannin counties, and parts of Habersham, White, Lumpkin, Dawson, Pickens, Gilmer, and Murray counties. The Blue Ridge enters the State in Rabun and Towns counties and loses its distinctively mountainous character in Pickens County. The region is vastly more complex geologically than either the Appalachian Valley or the Cumberland Plateau, being composed of igneous rocks and highly metamorphosed sediments that have been subjected to great orogenic movements, intense folding and faulting, and erosion since early geologic time. The topography is more rugged and more varied and shows greater irregularity in drainage and less dependence upon the strike of the rock. The highest elevation above sea level is about 5,000 feet, and a large number of the "balds" or knobs rise above 4,000 feet.

PIEDMONT PLATEAU.

The Piedmont Plateau lies between the Appalachian Mountains and the Coastal Plain. The general surface of the plateau inclines slightly seaward from elevations of 1,600 to 1,800 feet above sea level in the north to a slow as 400 feet in places in the south. The

teau surface, according to an oral statement of Mr. Arthur Keith, ivisible into at least two plains. The higher plain lies immediately ith of the Appalachian Mountains in portions of Stephens, Haber- am, Banks, Hall, White, Gwinnett, Forsyth, Lumpkin, Dawson, herokee, Pickens, Bartow, Gordon, and Gilmer counties, at eleva- ons of 1,200 to 1,800 feet above sea level. The lower plain includes he remainder of the plateau southward to the border of the Coastal Plain and is separated from the higher plain by an escarpment 100 to 200 feet high, which in most places is well defined. The plateau, like the Appalachian Mountain area, is a region of great rock complexity, but the beds, though subjected to intense folding and faulting, have been planated by erosion, and with the exception of a few conspicuous monadnocks the land presents an even sky line. The streams, which commonly conform to the slope of the plain, have deeply trenched their courses, so that, although the general upland is at an approximately concordant level, the surface in detail is broken or hilly, in places approaching mountain ruggedness.

COASTAL PLAIN.

GENERAL FEATURES.

The Coastal Plain of Georgia includes practically all the State lying south of a line passing through Augusta, Macon, and Columbus, an area of approximately 35,000 square miles. It forms a part of the Atlantic and Gulf Coastal Plain of the eastern United States.

Physiographically, the region is a low plain having a gentle southward slope. In comparison with the other physiographic divisions of the State this plain has been subjected to erosion for only a short time, and its topography over the greater part of the area may be described as youthful. On the whole the Coastal Plain is level, although it comprises some hilly and broken areas in the northern part near the fall line, where in places it is dissected and appears somewhat more mature. None of the hills, however, rise above a general level, and their tops present an even sky line. The rocks ar mainly unconsolidated sands, clays, and marls of simple structur and the region consequently lacks the pronounced topography du to resistant varieties of rock and the folding of beds that characteriz the Appalachian Valley and Appalachian Mountains. The plai reaches a maximum elevation above sea level of 650 to 700 fe between Macon and Columbus, and of 500 to 600 feet between Ma and Augusta, and thence slopes gradually 3 to 4 feet per mile to level. About one-half of the plain is less than 300 feet, and a la area near the Atlantic coast, about one-seventh of the total, is than 100 feet above sea level. Here the streams have not c deep courses as in the older divisions; tributary streams are

and large, flat, undrained or poorly drained areas abound, particularly in the southeastern part.

PHYSIOGRAPHIC SUBDIVISIONS.

Although the Coastal Plain may be described, in comparison with the Appalachian Valley, Appalachian Mountains, and Piedmont Plateau, as a plain, it is not entirely featureless, and within itself it presents topographic contrasts. It may be divided into six physiographic divisions—the fall-line hills, Dougherty plain, Altamaha upland, southern lime-sink region, Okefenokee plain, and Satilla coastal lowland. (See fig. 1.)

FIGURE 1.—Sketch map showing physiographic divisions of the Coastal Plain of Georgia.

FALL-LINE HILLS.

The fall-line hills, as is indicated by their name, occupy the upper portion of the Coastal Plain, their northern boundary being that of the sediments of the Coastal Plain or approximately the fall line, south of which the division forms a belt 40 to 50 miles wide across the State. This belt, however, is not sharply defined, for on the north it merges into the Piedmont Plateau and on the south into the level and less broken land of the Dougherty plain and the Altamaha upland. In the fall-line hills, more than in any other division, the

topographic features are due to surface erosion. Stream erosion is more active on account of the greater altitude and has been in progress for a greater period of time. The region is characterized by flat-topped hills or ridges and deep gullies or "washes." The larger streams have cut courses 200 to 350 feet below the level of the upland plain, and the northern portion of the belt is as broken as the adjacent Piedmont Plateau. The region is underlain mainly by sands and clays of Cretaceous and Eocene age and their softness has favored rapid erosion.

In elevation above sea level the higher land west of Ocmulgee River varies from approximately 350 to 700 feet; that east of the Ocmulgee from 300 to 600 feet. The elevations of low water at Columbus, Macon, Milledgeville, and Augusta are, respectively, 190, 279, 241, and 98 feet.

Two types of hills are commonly recognized, the sand hills and the red hills. The sand hills are best developed in the more northerly part of the belt and are conspicuous in Richmond, Crawford, Taylor, Talbot, Marion, and other counties, and are really no more than flat ridges which have a notable covering of gray or brownish sand. This sand is almost pure quartz, incoherent or loose, and varies in thickness from 3 to 30 feet, though its average thickness is perhaps not more than 5 to 6 feet. This sand is probably residual from the underlying Cretaceous and Eocene formations. The soil is poorly productive, and the tree growth is mainly stunted oak and scattered long-leaf pine.

The more southerly part of the fall-line belt consists mainly of red hills, in which the gray sand is less widely distributed. The soil of the hills is a bright-red sand or red sandy loam, which is residual from the underlying geologic formations, chiefly the Eocene. The red hills are conspicuous in Wilkinson, Twiggs, Houston, Macon, Sumter, Terrell, Randolph, and Stewart counties.

The deep gullies, also known as "washes" and "caves," which appear in places in this region, are worthy of note. The softness of the strata, together with the high altitudes of the plain above the rivers, the removal of the timber, and the cultivation of the land, have especially favored rapid erosion, and some of the deepest gullies, 100 to 175 feet, are known to have formed since the settlement of the country. The largest and most picturesque are located west and north of Lumpkin, Stewart County. The gullies at Providence, 8 miles west of Lumpkin, are 100 to 175 feet in depth and from 20 yards to one-fourth mile in length. Their greatest width is at t head, where a number of smaller gullies unite, so that in plan they a roughly bottle shaped or pear shaped. In transverse profile they a V-shaped, and in longitudinal profile roughly L-shaped, the horizon leg being, of course, much longer than the vertical—that is,

head of the gully is precipitous, and the gradient of the floor is so low that the load of sand which is washed down is not carried far away but is spread out in deltas and sand streams. (See Pl. I, *A*.) The strata in which the gullies are formed are unconsolidated sands containing soft clay layers and hence are easily eroded. The recession of the gullies has been very rapid, the deepest being known to have worked back 300 feet in about 30 years and to have washed out 10 or 15 acres. Single caves or slumps 5 to 10 feet wide have taken place after very heavy rainstorms. These gullies are the most picturesque features of the Coastal Plain, presenting curious erosion forms, pinnacles, "islands" or blocks, and sharp serrated ridges, cut off from the adjacent upland, the whole rendered the more striking by the vivid color contrast of the bright-red and white sands with the dark-green pine tops. Similar deep washes or gullies appear in Quitman, Webster, Marion, Crawford, Houston, Twiggs, Wilkinson, and Washington counties. The deep washes on the south side of Rich Hill, Crawford County, are, next to the Providence gullies, perhaps the most picturesque. The famous gullies 4 miles west of Milledgeville are properly within this area, although they are cut entirely in residual clay derived from granite, only a few remnants of sediments of the Coastal Plain appearing at this locality. These gullies, which are about 50 feet deep, were visited by Lyell in 1842 and were described by him in his Travels in North America.

DOUGHERTY PLAIN.

The Dougherty plain occupies a large area in the western part of the Coastal Plain, extending from the Chattahoochee to a few miles east of Flint River and including the greater part or all of the counties of Decatur, Miller, Mitchell, Early, Baker, Calhoun, Dougherty, Randolph, Terrell, Lee, and Sumter. A small strip extends eastward from the Flint to the Oconee, including parts of Dooly, Houston, Pulaski, and Laurens counties. The plain is characterized by very level tracts, containing few elevations that can properly be termed hills. Small streams and branches are comparatively few, and surface erosion is consequently slight, the drainage being in large measure subterranean. The surface is further characterized by numerous lime sinks, which form shallow depressions in otherwise level tracts. The Dougherty plain includes most of the area underlain by the limestones of the Vicksburg formation. It is rather sharply differentiated from the Altamaha upland on the east and south but merges into the fall-line hills on the north.

The elevation above sea level of the Dougherty plain varies from approximately 125 feet in Decatur County to 450 feet in the southern part of Houston County, much the greater portion being less than 300 feet.

The sinks vary in size from small shallow depressions not more than 100 to 200 feet in diameter to hollows occupying several hundred acres and to chains of sinks several miles in length. The sinks usually contain shallow ponds or lakes, and the smaller ones generally support a thick growth of cypress and other trees. The amount of water in the ponds and lakes varies with the seasons, and during droughts the smaller ones become dry. A recent desiccation of the sinks is partly attributed to the removal of timber, which permits increased evaporation and oxidation of organic matter. Sinks are also known to have been suddenly drained through subterranean passages.

The scarcity of small tributary creeks and branches is due not so much to the newness of the land surface as to the fact that much of the drainage is through subterranean streams. Most of the large creeks flow sluggishly through wide swampy valleys, and few of them have any considerable bluffs along their courses. Chattahoochee, Flint, and Ocmulgee rivers have cut deep terraced valleys 75 to 200 feet below the plain but have comparatively few tributary streams.

The main topographic features of the Dougherty plain have resulted from the relatively rapid removal in solution of the calcareous materials that form so large a part of the Vicksburg and the overlying Chattahoochee formation.

ALTAMAHA UPLAND.

The Altamaha upland constitutes the largest physiographic division of the Coastal Plain. Its northern boundary runs irregularly between Waynesboro, Tennille, Dublin, Cochran, and Vienna, and its western edge lies parallel to and a few miles east of Flint River for as far south as Decatur County. On the southeast, in Effingham, Liberty, Wayne, Pierce, Ware, and Clinch counties, it merges into the sandy pine flats of the Okefenokee plain. The division embraces most of the region popularly known as the wire-grass country and is underlain by the Alum Bluff formation and by the weathered residual products of that formation or by younger material of similar lithology. The geology, topography, and flora of this region are of peculiar scientific interest and have been the subject of numerous papers and articles.

The region can be called an upland only in comparison with the lo coastal plain on the southeast and the adjacent Dougherty plain c the west; on the whole it is lower than the fall-line hills to the nor It varies in elevation above sea level from about 470 feet in the nc and west to about 125 feet in the southeast, there being a gradual sl to the southeast. An ascent or escarpment prominent enough t

[1] Loughridge, R. H., Cotton production of the State of Georgia: Tenth Census, vol. 6, Georgia, and 49, 1884. Dall, W. H., U. S. Geol. Survey Bull. 84, p. 81, 1891. Harper, R. M., Phytogeogra sketch of the Altamaha grit region of Georgia: Annals N. Y. Acad. Sci., vol. 17, pt. 1, 1906. Mc S. W., Underground waters of Georgia: Georgia Geol. Survey Bull. 15, pp. 31–32, 1908. Veatc Altamaha formation of the Coastal Plain of Georgia: Science, vol. 27, pp. 71–74, 1908.

distinguished by the observant traveler without the aid of topographic maps separates the upland from the Dougherty plain on the west. The rise from Camilla to Pelham, Mitchell County, over the Atlantic Coast Line Railroad is 185 feet in 8 miles, and the rise from Bainbridge east to Climax is 175 feet. Arabi, in Crisp County, Sylvester, in Worth County, Pelham, in Mitchell County, and Climax, in Decatur County, may be considered as marking approximately the crest of the escarpment, from which the elevation gradually decreases to the southeast.

Characteristic of the topography are low rolling hills with smooth or softened outlines, which, except along the large rivers, do not rise more than 40 or 50 feet above the valleys. None of the features suggest ruggedness, yet at the same time the region is not monotonously level or flat.

The soil is generally sandy and the country in places is thickly mantled with loose gray sand. The area was originally covered with a wonderful forest of long-leaf pine. A characteristic growth is the long, round-bladed, stiff wire grass, *Aristida stricta*, which grows in tufts 6 to 8 inches high.

Streams are much more numerous than on the Dougherty plain and the coastal flats. Altamaha, Ocmulgee, and Oconee rivers have cut valleys 100 to 150 feet deep, bordered in a few places by precipitous bluffs, but except for these the valleys are shallow. Those of the small streams have low breastlike slopes and may be described as dish shaped. The creeks flow through broad swampy bottoms, are generally sluggish, and are characterized by clear water, free from sediment, in contrast to the muddy waters of the Ocmulgee, Oconee, and Altamaha. Many of the creeks and branches have their sources in flat, moist, densely wooded areas locally known as bays. The name "bay" is generally applied to upland, flat, swampy tracts due to imperfect drainage and dense vegetation which conserves the rainfall. These areas are really swamps but are not alluvial in character. Cluffs Bay, about 7 miles west of Waycross, is an example. The name is also applied to arms of creek and river swamps which form entrants into the dry land and which are characterized by a dense growth of bay trees. The bays contain water, but have no well-defined stream channels or runs, the water being furnished directly by rainfall and by seepage from the surrounding higher land.

In the southeastern part of the Altamaha upland the land is more level and finally merges into the moist pine flats of the Okefenokee plain. Throughout this part small cypress ponds are numerous, the valleys of the small streams are more swampy, and the streams themselves have banks not more than a foot or two high. The ponds appear to be the result of irregularities left in the land surface after the last retreat of the sea.

Along the northern and western edges of the Altamaha upland in Screven, Wilcox, Crisp, Turner, Worth, and Decatur counties, sinks, due to the underground solution of limestone, most probably that of the Chattahoochee formation, were noted.

Among the most interesting features of the Altamaha upland are the sand hills which border many of the creeks and rivers. These hills slope toward the streams, but many of them are only very slightly or not at all higher than the upland back from the stream. They are made up of gray, yellow, or light-brown, unconsolidated, structureless quartz sand, which in places reaches a thickness of 30 feet. Some of the sand belts are 2 or 3 miles wide. They run parallel to the streams, generally on the east or left side. These sand hills seem to stand at higher elevations than the loose sand on the first and second Pleistocene terraces of the large rivers. The most prominent are those on the east side of Ohoopee River, in Tattnall County, near Reidsville; along the east side of Canoochee River; on Little Ocmulgee River, near Helena; along Satilla River from Waycross westward; and on the east and north sides of Pendleton Creek, in Emanuel and Toombs counties. At the foot of some of these hills are densely wooded, moist sand beds known as hammocks and in places shallow depressions, so-called sand-hill ponds, which contain water during rainy periods. The origin of these sands is not yet well understood. They may have been formed during the Pleistocene epoch and may be of fluviatile origin, but they have since been in part shifted by wind.

In comparison with the Dougherty plain, the Altamaha upland has a rolling topography, more numerous streams, and fewer lime sinks. It is not so entirely featureless as the swampy tracts along the coast and is better drained. In contrast to the fall-line hills it lacks ruggedness, its valleys are shallower, and its flora is notably different.[1]

SOUTHERN LIME-SINK REGION.

The southern lime-sink region occupies a small area in the southern part of the State, embracing the southeastern part of Decatur County, the southern halves of Grady, Thomas, Brooks, and Lowndes counties, and adjacent areas in Florida. The topography is hilly and is characterized by lime sinks, lakes, and ponds.

The surface varies from 150 to 275 feet above sea level, and the hills rise 50 to 75 feet and in a few places 100 feet above the valleys. The topography is more rugged than that of the adjacent Altamaha upland and the Dougherty plain, this difference and other characteristics of the division being due mainly to the differences in the underlying geologic formations. The lime sinks are due to the under-

[1] Ecological studies in this region have been made by Dr. R. M. Harper. See Annals New York Acad. Sci., vol. 17, pt. 1, 1906.

A. "SAND STREAM" 1 MILE NORTH OF TAZEWELL, MARION COUNTY.
The sand has been transported by torrents from gullies in the Cusseta sand member.

B. SINK IN LIMESTONE OF THE CHATTAHOOCHEE FORMATION NEAR RECOVERY, DECATUR COUNTY.

A. SATILLA TERRACE PLAIN IMMEDIATELY WEST OF NEW SAVANNAH BLUFF, SAVANNAH RIVER, RICHMOND COUNTY.

An escarpment bounding the plain on the west appears in the distance.

B. SATILLA TERRACE PLAIN BORDERING ST. MARYS RIVER (FLORIDA SIDE), OPPOSITE TRADERS HILL, CHARLTON COUNTY.

The escarpment separates the terrace from the Okefenokee terrace plain.

ground solution of an upper Oligocene limestone, the Chattahoochee formation, which except in small areas is not the surface formation but which is overlain by 50 to 100 feet of sand and clay, whose soft and easily eroded character probably accounts for its greater ruggedness as compared with the western lime-sink region (Dougherty plain). The lakes and ponds occupy depressions caused by the collapse of underground solution caverns in limestones. (See Pl. I, *B*.) Some of the lakes cover areas of several hundred acres and are free from timber growth, but the smaller and shallower ponds support a thick growth of cypress. Ocean Pond, in the southern part of Lowndes County, is one of the largest, having an area of about 6 square miles. The water in these sinks varies with the seasons but has been known suddenly to disappear or to rise, owing probably to the opening or closing of underground passages.

The drainage, as in the Dougherty plain, is to some extent subterranean and small streams are not numerous. The rivers of the region, the Ochlockonee, the Withlacoochee, and other smaller streams, flow canal-like through broad sand-covered terrace plains. The water of the streams is not muddy but is dark on account of dissolved and suspended organic matter; that of the lakes is clear.

The soil is in many places red sandy clay. Superficial gray sand such as characterizes the Altamaha upland is not so widely distributed. The tree growth differs somewhat from that of the wiregrass region to the north, some oak and hickory being associated with the long-leaf pine.

OKEFENOKEE PLAIN.

The Okefenokee plain forms a north-south belt 20 to 40 miles wide in the southeastern part of the Coastal Plain, including parts of Effingham, Bryan, Liberty, Wayne, Pierce, Camden, Ware, Charlton, Clinch, and Echols counties. On the west it is bounded approximately by a line extending from the northeast corner of Effingham County southwestward nearly to Groveland, Bryan County, thence to a point a few miles south of Glenville, thence nearly to Jesup and Waycross, and thence along the western boundary of the Okefenokee Swamp. The escarpment separating the plain from the Altamaha upland is poorly defined, and in places the two seem to merge. On the east the plain is separated from a lower coastal terrace by an abrupt descent or escarpment. (See p. 36.)

The Okefenokee plain is essentially a featureless sandy flat, in which there are few streams and many cypress and gum ponds and swamps, whose areas range from a few acres or a few square miles to the immense expanse of the Okefenokee Swamp. (See pp. 39–42.) It thus presents a contrast to the rolling topography and dendritic drainage of the Altamaha upland. The Okefenokee plain varies in

elevation above sea level from about 60 to perhaps 125 feet, sloping eastward about 2 feet to the mile. The drainage is poor, at least 25 per cent of the area being swampy, and the few creeks and branches flow through broad swampy flats only slightly lower than the general level. At only a few places are the bluffs as high as 30 or 40 feet. The flatness of the plain and its swampy condition are due to the newness of the land surface, the retreat of the sea having taken place in comparatively recent geologic time, to the low altitude, and to the fact that the surface formation is a thick, loose, porous sand which absorbs the rainfall and hence lessens surface erosion. The streams are sluggish, and their waters, except those of the Altamaha and Savannah, are black or coffee-colored from organic matter. The region is characterized by moist long-leaf pine and saw-palmetto flats, cypress ponds, gallberry flats, and swamps supporting thick growths of gum and bay.

SATILLA COASTAL LOWLAND.

The Satilla coastal lowland or Satilla plain is a low marine terrace 20 to 35 miles wide that borders the Atlantic Ocean and includes part or all of the counties of Chatham, Bryan, Liberty, McIntosh, Glynn, and Camden. (See fig. 1, p. 29.) The western edge of the plain is marked by a rise of 20 to 40 feet, probably a Pleistocene shore line, which is prominent at Walthourville, Mount Pleasant, and Waynesville, and a short distance east of Folkston.

The greater part of the plain is 15 to 25 feet above sea level, but in a few places it reaches an elevation of about 40 feet. It has a slight eastward slope, somewhat difficult to estimate but generally less than a foot to the mile. Although the plain is low, flat, and poorly drained, it presents several different topographic aspects. It differs from the Okefenokee plain chiefly in its lower altitude, in its greater area of swamp and inundated land, and in its topographic forms, which are incident to low coast land.

The western part of the belt is on the whole a sandy flat plain containing an open growth of long-leaf pine. In the spring and summer grass and flowers are luxuriant in the open meadows or "savannas."[1] The surface is dotted with small cypress ponds and contains larg swamp areas, in this respect resembling the higher Okefenokee plai

Near the coast the plain presents a different aspect. Owing t recent submergence the coast line is irregular, and a network sea islands, tidal rivers, sounds, estuaries, and marshes has bee formed. The land terminates as beach on the sea islands, as sar bluffs not more than 10 or 15 feet above low tide, and as mars at the mouths of the rivers. The islands are sand covered, and so

[1] An excellent description is given by R. H. Loughridge, Cotton production of the State of Ge Tenth Census, vol. 6, Georgia, p. 51, 1884.

of them exhibit sand dunes, which, however, nowhere reach great magnitude. Their total area is perhaps 500 to 600 square miles. The largest are Cumberland, Jekyl, St. Simon, Sapelo, St. Catherine, Skidaway, and Tybee. They are of considerable historical interest and some of them are noted as resorts.

The tree growth of the coast land is characterized by the cabbage palmetto and live oaks, which are more abundant than farther west.

There are two classes of swamp land, upland and tidal. Swamps of the upland class, of which Buffalo Swamp, in the western part of Glynn County, is representative, probably occupy the sites of former shallow sounds or coastal lagoons and marshes which have become land through uplift and the retreat of the sea and which have not been inundated as a result of the later subsidence indicated by drowned-river courses. Other upland swamps are apparently once more becoming lagoons, for the subsidence seems to be still going on and the sea to be slowly encroaching on the land. The best proof of this is the presence of tree stumps and even dead standing trees in brackish-water marshes.

The second class, the tidal swamps, occur in considerable areas along Savannah, Ogeechee, Altamaha, Satilla, and St. Marys rivers. They differ from salt marshes chiefly in that at high tide they are partly covered by the backing up of the fresh river water instead of directly by the sea. They extend up the rivers 10 to 20 miles beyond the salt marshes, and rice growing is still carried on in these swamps, but to a much less extent than formerly.

The salt marshes reach their greatest extent at the mouths of the rivers, but probably do not aggregate more than 150 or 200 square miles.[1] They are probably due in the main to submergence of the coast, although the silting up of shallow water-covered areas by sediment carried down by streams has also doubtless been a factor.

The Satilla plain is poorly drained, owing to the newness of the land surface and its low altitude. The few streams are sluggish, and with the exception of Savannah and Altamaha rivers, whose waters are yellow from suspended sediment, are so-called clear-water streams, whose waters are, however, dark or even black from organic matter. Most of the streams flow eastward or southeastward, their courses having been determined by the general slope of the plain. Satilla and St. Marys rivers, however, in parts of their courses flow parallel to the coast—that is, at right angles to the terrace slope.

Slight submergence has drowned the streams, converting the mouths of the large rivers into estuaries navigable for sea-going vessels for 10 to 20 miles, and changing small streams, mere branches or creeks, so far as their lengths are concerned, into estuaries and

[1] No survey of the marshland of the State has yet been made, hence accurate figures can not be given.

so-called rivers. Among the latter are Crooked, Turtle, and Sapelo rivers. A network of serpentine waterways on the sea islands are termed creeks and, perhaps inappropriately, rivers.

MINOR FEATURES.

TERRACES.

The terraces constitute an interesting physiographic feature of the Coastal Plain. They are intimately connected with the Pleistocene geology of the region, and their nature, origin, and detailed extent are problems which demand further study with the aid of detailed topographic maps.

Two broad terrace plains, the Okefenokee and the Satilla (see pp. 35, 36), parallel the coast and are easily recognized. Not improbably a third higher terrace plain exists, but sufficient proof of its existence has not been obtained to warrant positive statements.

Fluviatile terraces, believed to be equivalent in age to the two coastal terrace plains, border the larger rivers. They are best developed in the upper part of the Coastal Plain along the Chattahoochee, Ocmulgee, and Savannah, and are conspicuous at Columbus, Macon, and Augusta. The lower or younger terrace, also known as "second bottoms," lies 15 to 50 feet above the rivers and is a smooth plain from half a mile to 4 miles in width. (See Pl. II, *A* and *B*.) The upper or older terrace, which lies 50 to 100 feet above the rivers, has been partly destroyed by the erosion that formed the lower terrace. The interstream uplands lie 125 to 300 feet or more above the rivers.

STREAMS.

The drainage of the Coastal Plain discharges into the Atlantic Ocean and the Gulf of Mexico. The main drainage basins are those of Savannah, Ogeechee, Altamaha, Satilla and St. Marys, Suwannee, Ochlockonee, and Apalachicola rivers, the last named being drained, in the State, by Chattahoochee and Flint rivers. The first four basins, which drain into the Atlantic, cover much the larger portion of the Coastal Plain of Georgia; the last three drain into the Gulf of Mexico.

On the basis of origin the rivers of the Coastal Plain fall into tw classes, those originating in the Piedmont Plateau and Appalachi Mountains and thence traversing the Coastal Plain, and those indig nous to or having their source within the Coastal Plain. To first class belong the Chattahoochee, Flint, Ocmulgee, Oco Altamaha, Savannah, and Ogeechee. To the second class, wh streams are smaller and more numerous, belong the Little Ocmul Ohoopee, Canoochee, Satilla, St. Marys, Suwannee, Alapaha, W lacoochee, and Ochlockonee. Throughout the greater part of

course Ogeechee River has much the aspect of a stream of the second class. (See fig. 2, p. 58.)

The rivers of the first class have greater drainage areas, carry a greater volume of water, have greater lengths, and have cut deeper and wider valleys. Their waters, except those of the Ogeechee, are always more or less muddy, whereas the waters of the streams of the second class are clear; and this fact furnishes a popular distinction—"clear-water"[1] and "muddy-water" streams. The Ocmulgee, Oconee, Altamaha, and Savannah are bordered by lowlands or swamps reaching maximum widths of 5 or 6 miles, in which a large part of the sediment is clay, whereas the smaller Coastal Plain rivers of the second class have sandy banks and are bordered by low terraces composed almost entirely of sand. The explanation is that streams of the first class have brought down a large amount of sediment derived from the red-clay hills of the Piedmont Plateau, whereas those of the second class flow wholly through areas where the geologic formations are predominantly sand and where erosion is less active, many of the smaller streams not having cut through even the superficial sands.

The rivers crossing the Coastal Plain probably assumed their present courses on a comparatively level plain as the sea retreated from the land. As geologic time proceeded each successive uplift of the land caused the river courses to extend farther southeastward to the new coast line. The age of the Ocmulgee at the fall line, for instance, is much greater than that of the Altamaha, which receives its waters and which, in the lower 20 or 30 miles of its course, flows across the later Pleistocene plain. The directions of the streams, which, with certain exceptions, flow south, southeast, and east, are due to the initial slope of the new land surfaces across which they flowed.

LAKES AND PONDS.

The lakes and ponds of the Coastal Plain are of three types—those due to lime sinks, those caused by original shallow depressions in the land surfaces after the retreat of the sea, and those formed on river flood plains.

Lime-sink lakes and ponds are confined mainly to the western and southwestern parts of the Coastal Plain—the Dougherty plain and the southern lime-sink region; some, however, are found in Screven County, in the southern parts of Burke, Jefferson, and Washington counties, and along the western edge of the Altamaha upland. The depressions which lakes and ponds of this type occupy result from

[1] Though the indigenous streams of the Coastal Plain are termed "clear," the water is clear only in that it is comparatively free from suspended silt and clay. It does not possess the transparency of clear mountain streams but is pale brownish or even black from organic matter held in solution and suspension. The water of Suwannee and St. Marys rivers, near their source, the Okefenokee Swamp, is almost inky.

the collapse of underground solution caverns in limestone; the process is still in operation and some of the sinks have formed since the settlement of these areas. These bodies of water vary in size from ponds 100 feet across to lakes 6 square miles in area. The shallow ponds often become dry and the water level in the larger and deeper ones varies considerably with the seasons. Some attain considerable depth and are connected by open passages with underground channels; for instance, a sink 90 feet deep, known as Forest Falls or the Limesink, 8 miles north of Whigham, Grady County, receives a small stream, which disappears through an opening in the bottom. Of the larger lakes the most notable are Ocean Pond and Long Pond in Lowndes County; Original Pond, 3 miles west of Metcalf; and Rock Pond, near Camilla, Mitchell County.

The ponds, many of them small and shallow, which occupy original depressions in level sandy plains, depend for their existence on seepage from the surrounding sands, and most of them become dry in times of severe drought. They are numerous in the southeastern part of the Altamaha upland, are typically developed on the Okefenokee plain, and are present on the Satilla marine-terrace plain 20 to 40 feet above sea level. Most of them support a growth of cypress and gum. Some rather large untimbered expanses of water in the Okefenokee Swamp, termed "lakes," also belong to this type.

Bodies of water which occupy abandoned channels in the flood plains of streams are of the type of the numerous lakes that occur along the lower course of the Mississippi. Most of them are long and curved, taking the form of oxbows and crescents. Many of them receive the flood waters of the streams and are therefore generally less clear than those of the lime-sink lakes and ponds. Some of them, as Hershman Lake in Screven County and Black Lake in Wilkinson County, maintain their connection with the parent stream.

FRESH-WATER SWAMPS.

The fresh-water swamps of the Coastal Plain may be included in two main classes, upland plain and fluviatile.

Upland-plain swamps.—The upland-plain swamps lie on the Okefenokee and Satilla plains and owe their existence to the flatness and consequent imperfect drainage of the land surface. They are upland in that they lie at higher levels than the river swamps, tid swamps, and salt marshes, although some of them are not mor than 20 feet above sea level.

Okefenokee Swamp, the largest of this class in Georgia, is perha the greatest natural wonder in the State. It lies in the southeast part of the Coastal Plain, in Ware, Charlton, and Clinch count and extends to the Florida line. It has a length of about 40 mi a width of 30 miles, and an area of 700 to 800 square miles. T

swamp has been fully explored by hunters and lumbermen, but no very extended descriptions of it have been published. The following excellent short description is that of R. H. Loughridge,[1] who was one of a party that made a partial survey of Okefenokee Swamp in 1875:

> This swamp has a width of 30 and a length of 40 miles, covering an area of about 500,000 acres. It is in reality an upland swamp, having an altitude of 120 feet above tidewater on St. Mary's River, 4 miles distant. A sand ridge (part of the water divide of the State) 30 feet above the swamp extends along its eastern border to the south, becoming lower as it reaches the southern horseshoe bend of St. Marys River. The swamp is highest on the northeast, and falls irregularly to the south and southwest from 126½ to 111½ feet at Ellicott's mound and on the southwestern corner.
>
> The eastern part, 12 miles in width, is an open "prairie" or marsh, largely covered with water, in which are long rushes and water lilies. Under its surface is a dense body of moss from 4 to 6 feet thick, the great mass of which is decayed, forming muck and peat. It is so dense that it will readily bear up a man's weight, merely sinking a little and rising for many feet around; hence the name of Okefenokee—"trembling earth." Small islands, covered with clumps of cypress, bay, and cassino, frequently occur. The western part of the swamp is mostly covered by cypress trees and a dense growth similar to that of the small swamps outside, so tied together by bamboo briers and vines as to be impenetrable except by slow and tedious cutting away with bush knives. Small open marshes, and also a number of large islands, are found throughout this region. These islands are quite level but are slightly elevated above the swamp lands and have a sandy soil, with an open timber growth of long-leaf pine and a very low undergrowth of saw palmetto, and are similar in every respect to the mainland. Their dimensions are 3 or 4 miles by from 1 to 2, and they are bordered by a low hummock land, on which there is a growth of magnolia, oak, etc. Hunters find deer and bear on these islands. The soil or bottom of the swamp proper seems to be but little else than white sand.

R. M. Harper[2] has recently published a description, illustrated from photographs, in which the literature, history of exploration, geography, vegetation, and other characteristics of the swamp are briefly set forth.

The swamp dates from middle Pleistocene time. It lies upon a terrace plain, which is correlative with a lower terrace plain lying from 15 to 40 feet above sea level and extending to the present coast. The western edge of the lower plain is marked by an escarpment which is prominent at Waynesville, Mount Pleasant, and Walthourville, and probably represents the shore line of the latest Pleistocene sea. The next higher plain, the Okefenokee, parallels the lower plain, extending 20 to 40 miles westward from the escarpment. It is believed to be a wave-cut plain similar to the lower one and to have been covered by the sea during middle Pleistocene time. Its western border, or the shore of the sea covering it, is not plainly marked, although a good topographic map would probably reveal it; but it is believed to have extended approximately from Clyo, in Effingham

[1] Cotton Production of the State of Georgia: Georgia, Tenth Census, vol. 6, p. 51, 1884.
[2] Pop. Sci. Monthly, June, 1909.

County, southward to a few miles above Hinesville, thence via Jesup, Offerman, and Waycross to the northern and western borders of Okefenokee Swamp. It consists of a deposit of sand, laid down along the coast of the sea and shaped into slightly irregular deposits by wave currents and wind. The plain itself retains the slightly uneven floor left by the retreating sea, on which low ridges and heaps of sand had been piled up as bars at the mouths of bays or as beach accumulations. One such sand ridge, extending along the east side of the swamp, acted as a dam to the drainage from the west and caused the waters to spread out over a broad area which vegetation rapidly converted into the Okefenokee Swamp.

Big Pond, 7 miles north of Baxley, Appling County, belongs to the upland, nonalluvial class of swamps and is probably somewhat similar in origin to Okefenokee Swamp and to the smaller cypress and gum ponds which are so numerous in the southeastern part of the Coastal Plain. Although locally termed "pond," it is more properly a swamp. Its only open water is a small lake in its interior, reported to be not more than 100 yards long, the area as a whole being thickly covered with cypress, gum, pine, and an undergrowth of small trees and bushes. Big Pond lies upon a flat, sandy, pine-covered plain, about 200 feet above sea level. Its area, including a small swamp known as Second Pond, is about 8 square miles. The two "ponds" are connected by a narrow swamp known as Tiger Bay. On the east side of the swamps is a low ridge covered with superficial gray sand reaching a thickness of about 10 feet. Tenmile Creek, a small tributary of Altamaha River, flows sluggishly from the southern end of Big Pond.

Some swamps lying on the lower coastal terrace plain 15 to 25 feet above sea level appear to be the survivors of ancient lagoons or shallow sounds. Buffalo Swamp, in the western part of Glynn County, is an example. This swamp extends from Altamaha River southward to Turtle River and has a much greater length than width. It contains clay and is slightly lower than the sandy pine and palmetto land on both sides. Oyster shells in the clay bear evidence of its marine origin. Cabbage palmetto trees near Bladen and Everett are possibly survivors from the period when this area was a sound or marsh. The area is often entirely covered with water during the rainy season but becomes almost dry in times of drought. Should the present coast be elevated 20 or 30 feet the waterways and marsh between St. Simon Island and the mainland would probably become such an area as Buffalo Swamp.

Fluviatile swamps.—The fluviatile swamps occur on the flood plains of the streams. Nearly all the streams of the Coastal Plain, even the small branches, are bordered by swamps, the most extensive lying along the large rivers The swamp lands lie only a few

above the rivers and the frequent overflows and poor drainage maintain them in a swampy condition. Along the lower part of Savannah River the swamp reaches a width of 5 to 6 miles, the greater part being on the South Carolina side of the river. It supports a dense growth of oak, ash, cypress, gum, and pine. Other broad areas of swamp land lie along the Ogeechee, Altamaha, Oconee, Ocmulgee, and the upper part of the Flint. Chattahoochee River forms an exception to the general rule, having scarcely any land along its course in Georgia which can be termed "swamp."

The small branches, creeks, and rivers flow through broad, densely wooded lowlands, the water often spreading out among the trees until it is difficult to determine just where the channel proper is located. On many roads crossing the valleys of such streams it is necessary to construct a succession of low bridges a quarter of a mile to a mile long, alternating with stretches of earth embankment. Swamps of this character are notable along Ogeechee River; Williamson Swamp creek, in Jefferson County; Commissioner Creek, in Wilkinson County; and along the headwaters of Little and Alapaha rivers, in Tift, Irwin, and Berrien counties.

The area of fluviatile, or river and creek, flood-plain swamp in the Georgia Coastal Plain is perhaps 1,000 square miles [1] most of which lies 2 to 8 feet above the water level of the streams.

SPRINGS.

A few large springs are of physiographic and geologic interest. These springs are in limestone areas and seem to be connected with subterranean streams. Their water is clear and very transparent, though faintly bluish in color, is but little affected by rains, and probably comes from considerable depths. At Blue Spring, 4 miles south of Albany, the water rises under pressure through a roughly circular opening in limestone and has an enormous flow. Discharge measurements by B. M. and M. R. Hall [2] varied from 26.4 second-feet to 135 second-feet, or approximately 18,000,000 to 87,000,000 gallons in 24 hours. The spring is the largest in the State. Similar springs are Blue or Wade Spring, 7 miles east of Quitman; McIntyre Spring, on the Withlacoochee near the Florida line; Blue or Russell Spring, in Decatur County; Well, Wilkes, and Rock springs, in Laurens County; and Magnolia Spring, in Jenkins County. These are all large springs rising through limestone caverns.

Small springs, both permanent and intermittent, of minor importance, are numerous except along the coastal lowlands.

[1] No complete survey of the swamp lands of Georgia has been made, and the figures are only a rough estimate based on a knowledge of the approximate widths of the swamps along the largest rivers and creeks.

[2] U. S. Geol. Survey Water-Supply Paper 197, p. 236, 1907.

ELEVATIONS.[1]

The Columbus, Talbotton, and Milledgeville quadrangles of the United States Geological Survey cover small areas along the northern border of the Coastal Plain in Georgia. The remainder of the Coastal Plain in this State has not been mapped topographically. The elevations given below will therefore be of interest and of practical value to those engaged in working out geologic problems and in studying the underground waters of the State. The list has been compiled for the most part from published data, though several of the elevations given are merely rough estimates based on other elevations and on knowledge of the topography, supported in a few instances by aneroid barometer readings. Some may be several feet in error.

Elevations in Georgia.[2]

The abbreviations used are: A. B. & A., Atlanta, Birmingham & Atlantic Railroad; A. C. L., Atlantic Coast Line Railroad; C. of Ga., Central of Georgia Railway; Ga. R. R., Georgia Railroad; G. S. & F., Georgia Southern & Florida Railway; L. & N., Louisville & Nashville Railroad; M. D. & S., Macon, Dublin & Savannah Railroad; S. A. L., Seaboard Air Line Railway; U. S. A. Eng., United States Army Engineers; U. S. G. S., United States Geological Survey.

Abbeville	Rough estimate	225 ?
Abbeville (low water, railroad bridge)	U. S. A. Eng.	169.33
Achord	U. S. G. S.	274
Acree, Dougherty County	A. C. L.	205
Adams Park	U. S. G. S.	259
Adel	G. S. & F.	246
Adrian, Emanuel County	Rough estimate	290 ?
Albany	C. of Ga.	184
Albany (Flint River level)	A. C. L.	127
Alapaha	A. C. L.	293
Alexanderville	A. C. L.	153
Allentown	M. D. & S.	411 ?
Ambrose, Coffee County	A. B. & A.	395
Americus	C. of Ga.	360
Andersonville	C. of Ga.	394
Arabi	G. S. & F.	460
Argyle	A. C. L.	161
Arlington	Rough estimate	275
Armena	S. A. L.	275 ?
Ashburn	G. S. & F.	450
Augusta (Union Station)	City engineer	143
Augusta (river gage)	Weather Bureau	100
Baconton	A. C. L.	160
Bainbridge	A. C. L.	110
Bainbridge (river level)	Rough estimate	8
Bartow	C. of Ga.	23
Bath, Richmond County	Rough estimate	40

[1] Reprinted, with a few additions, from the work of Mr. Veatch published in Geol. Survey Georgia 26, pp. 50–57, 1908.

[2] Compiled chiefly from Dictionary of altitudes in the United States, by Henry Gannett, U. S Survey Bull. 274, 1908; from the list of elevations in Water powers of Georgia, Geol. Survey Georg 3–A; from surveys by the U. S. Corps of Engineers of Ocmulgee, Oconee, Altamaha, and Savanna and from the Columbus, Talbotton, and Milledgeville topographic sheets of the U. S. Geological

Baxley	U. S. G. S	206	
Belair	Ga. R. R.	295	
Berzelia	Ga. R. R.	488	
Blackshear	A. C. L.	106	
Bladen	S. A. L.	22	
Blakely	Rough estimate	275	
Blakely	Weather Bureau	300	
Bloomingdale	C. of Ga.	24	
Bonaire	G. S. & F.	354	
Boston	A. C. L.	194	
Bostwick (Paschal)	C. of Ga.	669	
Boulogne, Fla	A. C. L.	70	
Box Springs	U. S. G. S.	364	
Braganza	A. C. L.	144	
Brentwood	U. S. G. S.	167	
Brewer (Tusculum post office)	C. of Ga.	134	
Brookfield	A. C. L.	332	
Brooklyn	S. A. L.	691	
Brinson	A. C. L.	104	
Brunswick	Southern Ry	13	
Brunswick (city hall)	U. S. G. S.	11	
Buena Vista	Rough estimate	590	
Bullards	U. S. G. S.	259	
Burroughs	A. C. L.	19	
Bushnell	A. B. & A.	385	?
Butler	C. of Ga.	650	
Byromville	A. B. & A.	365	?
Byron	C. of Ga.	515	
Cairo	A. C. L.	237	
Camak	Ga. R. R.	578	
Cameron	C. of Ga.	103	
Camilla	A. C. L.	167	
Cairs station	U. S. G. S.	500	
Cecil	G. S. & F.	250	
Chauncey	U. S. G. S.	300	
Chula	G. S. & F.	395	
Claxton	S. A. L.	194	?
Clifton	C. of Ga.	22	
Climax	A. C. L.	277	
Clyo	S. A. L.	74	
Cochran	U. S. G. S.	342	
Coldbrook, Effingham County	Brinson R. R.	65	
Coleman	C. of Ga.	391	
Coley	Southern Ry	303	
Collins	S. A. L.	238	
Colon	G. S. & F.	137	
Colquitt	Rough estimate	175	
Columbus (Union Station)	C. of Ga.	260	
Columbus (river level)	U. S. G. S.	200	
Cordele	G. S. & F.	336	
Crescent	Rough estimate	18	
Culverton	Ga. R. R.	549	
Cusseta	S. A. L.	540	
Cuthbert	C. of Ga.	446	

Cutler	G. S. & F.	78	
Cuyler	S. A. L.	37	?
Cycloneter	G. S. & F.	410	
Dakota	G. S. & F.	410	
Darien	Rough estimate	15	
Dasher	G. S. & F.	185	
Davis	A. C. L.	238	
Davisboro	C. of Ga.	302	
Dawson	C. of Ga.	352	
Dearing	Ga. R. R.	464	
Devereux	U. S. G. S.	577	
Dewitt	Butt's map	175	
Dixie	A. C. L.	130	
Dock Junction	U. S. G. S.	25	
Doctortown	A. C. L.	74	
Doctortown (low-water level)	U. S. A. Eng.	31.	72
Donaldsonville	A. C. L.	139	
Douglas	A. B. & A.	388	?
Doublerun	A. B. & A.	363	?
Dover	C. of Ga.	104	
Dry Branch	M. D. & S.	368	?
Dublin	M. D. & S.	[1]231	?
Dublin (low-water level)	U. S. A. Eng.	160.	6
Dudley	M. D. & S.	325	?
Dupont	A. C. L.	180	
East Albany	A. C. L.	186	
Eastman	U. S. G. S.	357	
Eden	C. of Ga.	34	
Egypt	C. of Ga.	132	
Eldorado	G. S. & F.	340	
Elko	G. S. & F.	443	
Ellabelle	S. A. L.	93	?
Ellaville	J. W. Spencer	591	
Empire	U. S. G. S.	382	
Enigma	A. C. L.	309	
Esquiline	U. S. G. S.	300	
Eufaula, Ala	C. of Ga.	211	?
Everett City	U. S. G. S.	16	
Everett station, Crawford County	C. of Ga.	362	
Everett station (Flint River railroad bridge)	C. of Ga.	337	
Exeter	A. C. L.	94	
Exley	S. A. L.	63	
Faceville	A. C. L.	296	
Fargo	G. S. & F.	116	
Fitzgerald	A. B. & A.	388	?
Fitzpatrick	M. D. & S.	541	?
Fleming	A. C. L.	22	
Flint	A. C. L.	168	
Folkston	A. C. L.	80	
Fort Gaines	C. of Ga.	163	
Fort Gaines (river level, low water)		100	

[1] Elevations on the M. D. & S. R. R. are taken from the list given in Water-powers of Georgia: Ge Survey Georgia Bull. 3-A, pp. 98-100. Rough corrections were made according to the bench mark est lished on Oconee River at Dublin by U. S. Army Engineers.

Fort Mudge	A. C. L.	134	
Fort Valley	C. of Ga.	522	
Fowltown	A. C. L.	289	
Gallemore (Willis post office)	M. D. & S.	394	?
Gardi	U. S. G. S.	62	
Geneva (station)	U. S. G. S.	581	
Georgetown	C. of Ga.	189	
Georgetown (low water, Chattahoochee River)	Rough estimate	111	?
Glenmore	A. C. L.	151	
Godwinville	U. S. G. S.	312	
Gordon	C. of Ga.	348	
Gordon, Ala.	A. C. L.	160	
Graham	Southern Ry.	240	
Graves	C. of Ga.	350	
Greens Cut	C. of Ga.	284	
Griswold	C. of Ga.	447	
Grovania	G. S. & F.	444	
Groveland	S. A. L.	162	?
Grovetown	Ga. R. R.	495	
Guyton	C. of Ga.	81	
Hagan	S. A. L.	186	?
Hahira	G. S. & F.	230	
Halcyondale	C. of Ga.	110	
Halloca	U. S. G. S.	323	
Hardaway	A. C. L.	183	
Hardeeville, S. C.	A. C. L.	21	
Harlem	Ga. R. R.	548	
Harrison, Washington County	Weather Bureau	245	
Hatcher	C. of Ga.	289	?
Hawkinsville	Weather Bureau	235	
Hawkinsville (low-water level)	U. S. A. Eng.	200.	2
Haylow	G. S. & F.	167	
Hazlehurst	U. S. G. S.	256	
Helena	U. S. G. S.	247	
Hephzibah	Weather Bureau	402	
Herndon	C. of Ga.	179	
Homerville	A. C. L.	176	
Howard	C. of Ga.	666	?
Howell	G. S. & F.	169	
Inaha	G. S. & F.	415	
Irwinton	Rough estimate	460	?
Isabella (Sylvester)	A. C. L.	370	
Jasper, Fla.	A. C. L.	152	
Jeffersonville	M. D. & S.	526	
Jennings, Fla.	G. S. & F.	150	
Jesup	U. S. G. S.	100	
Johnsonville, Jeff Davis County	Southern Ry.	240	
Juniper station	U. S. G. S.	422	
Kathleen	G. S. & F.	330	
Kildare, Effingham County	Brinson R. R.	133	
Kingsland	S. A. L.	41	
Kirkland	A. C. L.	200	
Knoxville	J. E. Thomas	640	

Lake Park	G. S. & F	160
Lawton	C. of Ga	225
Leary	D. L. Wardroper	210
Leesburg	Rough estimate	300 ?
Lenox	G. S. & F	300
Lewiston	C. of Ga	385
Lily	A. B. & A	364 ?
Longstreet	U. S. G. S	302
Louisville	Weather Bureau	259
Ludowici	A. C. L	71
Lulaton	Rough estimate	50
Lumber City	U. S. G. S	146
Lumber City (river level, low water)	U. S. A. Eng	84.7
Lumpkin (station)	Rough estimate	500
Lumpkin	Weather Bureau	650
Lyons	S. A. L	254
McBean Station	C. of Ga	134 ?
McClenny, Florida	S. A. L	125
McDonald	A. C. L	167
McGriff	U. S. G. S	259
McIntosh	A. C. L	22
McRae	U. S. G. S	230
McIntyre	C. of Ga	261
Macon (Union Station)	G. S. & F	334
Macon (near Southern Ry. station)	U. S. G. S	311
Macon (low-water level)	U. S. A. Eng	279.02
Macon Junction	C. of Ga	350
Manassas	S. A. L	217
Marshallville	C. of Ga	500
Marlow	C. of Ga	72
Mayday	G. S. & F	140
Mayfield	Ga. R. R	417.5
Meigs	A. C. L	341
Meinhard	S. A. L	19
Meldrim	C. of Ga	28
Melrose	G. S. & F	154
Metcalf	A. C. L	170
Midville	C. of Ga	186
Milledgeville	Ga. R. R	276
Milledgeville (low-water level)	U. S. A. Eng	241.28
Millen	C. of Ga	156
Millwood	A. C. L	160
Mineola	G. S. & F	220
Moniac	G. S. & F	114
Monteith	A. C. L	16
Montezuma	C. of Ga	300
Montrose	M. D. & S	391
Morgan	Weather Bureau	337
Morris	C. of Ga	242
Mount Pleasant	Southern Ry	59
Munnerlyn	C. of Ga	264
Muscogee	U. S. G. S	245
Myers, Effingham County	S. A. L	45
Naylor	A. C. L	192

Nicholls	A. B. & A.	306 ?
Norwood	Ga. R. R.	588
Ochillee	U. S. G. S.	273
Ochlockonee	A. C. L.	263
Ochwalkee (low water, Oconee River)	U. S. A. Eng.	114.4
Oconee	C. of Ga.	223
Odum	U. S. G. S.	155
Offerman	A. C. L.	106
Ogeechee	C. of Ga.	111
Oglethorpe	C. of Ga.	299
Ohoopee	S. A. L.	187
Oliver	C. of Ga.	140
Omaha (station)	Rough estimate.	240
Ousley	A. C. L.	148
Paramore Hill	C. of Ga.	235
Parrott	S. A. L.	482
Paschal	C. of Ga.	669
Patterson	A. C. L.	104
Pearson	A. C. L.	205
Pelham	A. C. L.	355
Pembroke	S. A. L.	101
Pendarvis	U. S. G. S.	85
Pennick	U. S. G. S.	18
Perkins	C. of Ga.	252 ?
Pikes Peak (station)	M. D. & S.	534
Pinegrove	U. S. G. S.	229
Pinehurst	G. S. & F.	390
Pineora	C. of Ga.	78
Piscola, Brooks County	Weather Bureau.	190
Pooler	C. of Ga.	23
Poulan	A. C. L.	345
Powersville	C. of Ga.	385
Quitman	A. C. L.	173
Racepond	A. C. L.	148
Rebecca	A. B. & A.	373 ?
Recovery	A. C. L.	189
Register	Rough estimate.	225 ?
Renfroes	S. A. L.	601 ?
Reynolds	C. of Ga.	433
Riceboro	Rough estimate.	15
Richland	S. A. L.	600
Richwood	G. S. & F.	358
Rincon	S. A. L.	75
River Junction, Fla	L. & N.	84
Roberta	Rough estimate.	620
Roberts station	Ga. R. R.	557
Rockyford	C. of Ga.	130
Rogers	C. of Ga.	159
Saffold	A. C. L.	105
Saffold (level of Chattahoochee River)	Rough estimate.	65
St. George	G. S. & F.	78
St. Marys	Rough estimate.	12
Sandersville	Rough estimate.	470

Satilla	A. C. L.	96	
Satilla (river level)	A. C. L.	71	
Savannah	A. C. L.	21	
Scarboro	C. of Ga.	147	
Schlatterville	A. C. L.	133	
Scotland	U. S. G. S.	142	
Screven	A. C. L.	124	
Shell Bluff Landing, Burke County	U. S. A. Eng. (low water)	87	
Shell Bluff Landing, Burke County	U. S. A. Eng. (highest point)	237	
Shellman	C. of Ga.	379	?
Sibley	G. S. & F.	440	
Sisters Ferry (Savannah River), Effingham County	U. S. A. Eng. (low water)	20.03	
Smithville	C. of Ga.	332	
Sofkee	G. S. & F.	370	
Soperton	Rough estimate	290	
Sparks	G. S. & F.	241	
Sparta	Ga. R. R.	557	
Springfield	Rough estimate	100	
Statesboro	Rough estimate	175 to 200	
Sterling	U. S. G. S.	21	
Stillmore (highest land)	Rough estimate	300	
Stillwell, Effingham County	S. A. L.	69	
Stockton	A. C. L.	187	
Sulphur Springs	U. S. G. S.	300	
Sumner	A. C. L.	373	
Sunhill	C. of Ga.	362	
Surrency	U. S. G. S.	187	
Swift Creek	M. D. & S.	324	?
Sycamore	G. S. & F.	415	
Sylvania	Rough estimate	200	
Sylvester	A. C. L.	370	?
Talbotton	U. S. G. S.	726	
Tarrytown	Rough estimate	290	?
Tennille	C. of Ga.	469	
Thalman	Rough estimate	20	
Thelma	G. S. & F.	158	
Thomas	C. of Ga.	285	
Thomasville	A. C. L.	250	
Thomson	Ga. R. R.	503	
Tifton	A. C. L.	370	
Tivola	G. S. & F.	300	
Toomsboro	C. of Ga.	227	
Towns	U. S. G. S.	128	
Tusculum	C. of Ga.	134	
Tyty	A. C. L.	332	
Unadilla	G. S. & F.	412	
Upatoi	U. S. G. S.	418	
Uptonville	A. C. L.	83	
Valambrosa	M. D. & S.	258	?
Valdosta	A. C. L.	215	
Valona, McIntosh County	Weather Bureau	10	
Vidalia	S. A. L.	257	?
Vienna	G. S. & F.	350	

Wadley	C. of Ga	234
Wainwright (Uptonville station)	A. C. L.	83
Walden	C. of Ga	390
Walthourville	A. C. L.	95
Waresboro	A. C. L.	121
Warrenton	Ga. R. R.	500
Waverly	S. A. L.	17
Waycross	A. C. L.	140
Waynesboro	C. of Ga	286
Waynesville	A. C. L.	55
Ways	A. C. L.	18
Wellston	G. S. & F.	315
Wenona	G. S. & F.	348
Westlake	U. S. G. S.	235
Weston	S. A. L.	528
Wheaton, Appling County	U. S. G. S.	201
Whigham	A. C. L.	265
Whiteoak	S. A. L.	19
Willis (Gallemore)	M. D. & S.	394 ?
Weston	S. A. L.	528
Wilcox	Southern Ry.	116
Willacoochee	A. C. L.	247
Willingham	A. C. L.	319
Winchester	C. of Ga	463
Woodbine	S. A. L.	20
Worth	G. S. & F.	415
Wray	A. B. & A.	392 ?

GEOLOGY.

GEOLOGIC PROVINCES.[1]

Georgia may be divided into three major geologic provinces: (1) The Paleozoic area; (2) the crystalline area; (3) the Coastal Plain. The Coastal Plain, the largest of the three, covers approximately 35,000 square miles.

The rocks of the Paleozoic area are limestones, shales, and sandstones, which have been subjected to great dynamic movements and have been strongly folded and faulted. They range in age from Lower Cambrian to Pennsylvanian.

The rocks of the crystalline area, which includes the Piedmont Plateau and the Blue Ridge, are of igneous or metamorphic origin and include granites, gneisses, schists, basic eruptives, and highly metamorphosed shales, sandstones, and limestones. They constitute the oldest rocks of the State and are probably in the main of pre-Cambrian age. They have been subjected to great orogenic movements, have been folded, faulted, and otherwise profoundly altered.

The rocks of the Coastal Plain are sands, clays, marls, and, subordinately, limestones and sandstones. They are largely unconsolidated and are comparatively little altered from their original condition. Pronounced folding and faulting are entirely absent. The sediments of the Coastal Plain are the youngest beds in the State. They range in age from Lower Cretaceous to Recent and lie upon the upturned, planated rocks of the ancient crystalline complex. They are mainly marine deposits, the component materials of which were derived from the crystalline rocks to the north, their bulk representing the erosion of a vertical thickness of 2,000 feet or more. The boundary between these two major provinces, the Coastal Plain and the crystalline area, is known as the fall line.

DEPOSITS OF THE COASTAL PLAIN.

STRATIGRAPHIC SUCCESSION.

The deposits of the Coastal Plain underlie an immense area and have an estimated maximum thickness of 4,500 to 5,000 feet, the aggregate of separate strata which vary lithologically and faunally. A table of the subdivisions recognized in Georgia is given on pages 53–55, the areal distribution of the formations is shown on the map (Pl. III), and the general structure and relations of the deposits are shown in two sections (Pl. IV).

[1] The text of this report from pages 52 to 59, inclusive, with the addition of the sections shown on Pl. IV and some minor changes, is essentially a reprint from the report of Mr. Veatch in Georgia Geol. Survey Bull. 26, pp. 58–65, 1908.

Geologic formations in the Coastal Plain of Georgia.

System.	Series.	Group.	Formation.	Member.	Thickness.[a]	Character.	Importance as an aquifer.	
	Recent.				*Feet.*	Flood-plain deposits, alluvial sands, marsh mud, swamp deposits, and beach sand.		
Quaternary.	Pleistocene.	Columbia.	Satilla formation.		10–50	Near the coast, mud and sand containing marine shells. Fluviatile phase, coarse sand, gravel, and clay.	Contains beds yielding nonartesian waters.	Yield nonartesian waters in parts of Effingham, Screven, Bulloch, Bryan, Tattnall, Liberty, Wayne, Appling, Pierce, and Ware counties.
			Okefenokee formation.		5–40	Coastal-terrace phase, gray sand of perhaps beach origin, argillaceous sand, and small amount of gravel. Fluviatile phase, coarse sand and gravel.	Contains beds yielding nonartesian waters.	
			Unconformity.					
Tertiary.	Pliocene(?)		Charlton formation.		Undetermined.	Soft, white argillaceous limestone, and laminated, fossiliferous, greenish clay; the deposits are exposed only in the bluffs of St. Marys River.	Importance not known.	
	Miocene.		Duplin marl.		10–15	Sandy shell marl, slightly phosphatic.	Importance not known. Buried undifferentiated Miocene strata in the region adjacent to the coast are believed to contain water-bearing beds of importance.	
			Unconformity.					
			Marks Head marl.		45	Very sandy greenish and drab clay, fine gray and brownish phosphatic sand, and sandy laminated clays with calcareous nodules.		
			Unconformity.					
	Oligocene.	Apalachicola.	Alum Bluff formation.		150–200	Marine, containing fossils, greenish or gray argillaceous sand, and sandy laminated clays.	Contains local water-bearing beds.	
			Chattahoochee formation.		150	Gray and drab compact fossiliferous limestone. Siliceous replacements at the base contain a rich coral fauna.	Contains beds yielding large quantities of artesian water suitable for domestic and for most industrial purposes.	
			Unconformity.					

[a] Precise measurements can not be given; the reader is referred to the text for a discussion of the thickness of the various formations and members.

Geologic formations in the Coastal Plain of Georgia—Continued.

System.	Series.	Group.	Formation.	Member.	Thickness.	Character.	Importance as an aquifer.
Tertiary.	Oligocene.		Vicksburg formation.		*Feet.* 300	Mainly heavy-bedded, soft, white fossiliferous limestone, extensively silicified, overlain by red residual sand containing flint fragments. Contains also sand and clay beds.	Contains beds yielding large quantities of artesian and nonartesian water suitable for domestic and for most industrial purposes.
	Eocene.		Jackson formation.		150	Soft heavy-bedded fossiliferous limestone and calcareous and glauconitic sandy clay.	Contains beds yielding artesian waters suitable for domestic and for most industrial purposes.
		Claiborne.	Barnwell sand.		100	Mainly red and varicolored fossiliferous marine sand; thin beds of silicified limestone or chert and sandstone and quartzite.	In the area of outcrop contains beds yielding nonartesian waters. The buried coastward extension of the group as a whole contains numerous beds yielding large quantities of artesian water suitable for domestic and for most industrial purposes.
			McBean formation.	Marls, sand, etc.	100–400 (max.)	Variable in lithologic character; mainly argillaceous sandy fossiliferous marl, drab, sandy clays, and fuller's earth.	Contains numerous beds yielding artesian and nonartesian waters suitable for domestic and for most industrial purposes.
				Congaree clay member.			
			Unconformity—				
			Wilcox formation.		150 (max.)	Dark-colored lignitic and glauconitic clay o the nature of fuller's earth and varicolored unconsolidated sand and clay.	Contains water-bearing beds; importance not ascertained.
			Unconformity—				
			Midway formation.		400?	Ferruginous sand and local beds of white clay, together with fossiliferous limestone, marl, clay, and calcareous quartzite.	Contains beds yielding fairly large quantities of artesian and nonartesian waters suitable for domestic and for most industrial purposes.
			Unconformity—				

Cretaceous.	Upper.		Ripley formation.	Providence sand member.	950 (approx.)	Gray calcareous, micaceous sand; dark-gray to black sandy clay and shell marl with, at intervals, nodular layers of gray calcareous sand or impure sandy limestone of marine origin; fine to coarse cross-bedded sand with subordinate lenses of light-colored clay or dark lignitic clay of shallow-water origin.	The Cusseta sand and Providence sand members of the formation contain numerous beds yielding large quantities of artesian and nonartesian water suitable for domestic and industrial purposes; the marine beds contain some water-bearing beds.
				Marine beds.			
				Cusseta sand member.			
			Eutaw formation.	Tombigbee sand member.	560	Calcareous sand, sandy limestone, and more or less sandy clay of marine origin; cross-bedded sands and clays of shallow marine or estuarine origin; at base, arkosic, micaceous sand and dark-gray to black clay containing lignite.	The strata below the Tombigbee sand member contain beds yielding fairly large quantities of artesian and nonartesian water suitable for domestic and for most industrial purpose .
				Beds below Tombigbee sand member.			
			Unconformity				
	Lower.		Not differentiated.		350–600	Coarse-grained, cross-bedded, arkosic sand with subordinate lenses of light-colored to pure white clays, approaching kaolin in composition; contains no marine fossils and is of shallow near-shore origin, or perhaps in part of continental origin.	Contains numerous beds yielding large quantities of water suitable for domestic and industrial purposes.
			Unconformity				
Pre-Cambrian						Crystalline rocks.	

The great geologic periods Cretaceous, Tertiary, and Quaternary are based on the life forms preserved in the rocks and on the great physical or climatic changes that have taken place on the earth. The broader subdivisions, such as Lower Cretaceous, Upper Cretaceous, Eocene, and Oligocene, are based mainly on the forms preserved in the rocks and are also of world-wide application. Further subdivisions are provincial, and still further minor subdivisions are local and are based upon fossils, peculiar lithologic characters, stratigraphic continuity, surface configuration, or physiography, or a combination of some or all of these. To attempt to recognize mappable minor subdivisions of the strata either by their fossils or their lithology leads to confusion. The fossils are studied because of their value in correlating deposits of widely separated localities, the identity of which it is not possible to prove by stratigraphic continuity or actual tracing.

Sections in Mississippi, Alabama, and Florida have been taken as standards of comparison for the formations of Georgia for the reason that stratigraphic studies were first prosecuted in those localities. For the sake of uniformity and to avoid confusion the accepted geologic names employed to designate the formations and groups which extend from the States mentioned into Georgia are adopted in this report.

The general lithologic character and thickness of the subdivisions are shown in the table on pages 53–55. Their aggregate thickness is 4,500 to 5,000 feet, of which 2,000 to 2,500 is Cretaceous, approximately as much more is Tertiary, and probably not more than 100 feet is Quaternary. Precise measurements of thickness can not be given, chiefly because of the inconstancy of the strata both along the strike and dip, the merging of strata faunally and lithologically, the paucity of fossil remains, and the paucity of natural exposures.

STRUCTURE.

Dip and strike.—The strata of the Coastal Plain dip southeastward and southward and the older formations strike northeastward. The dip of the Oligocene and Eocene strata and probably that of the Cretaceous strata also becomes flatter toward the south and southeast. (See Pl. IV.) A little to the north of the Florida line the strata become horizontal, and at the Florida line they appear to be slightly reversed and to be inclined to the north or northwest.

The general slope of the surface, independent of the dip of the geologic formations, from the fall line to sea level, is about 3 feet to the mile. The slope of the crystalline floor at the fall line is 30 to 75 feet to the mile, but whether this slope is constant as far as the

present coast can only be a matter of speculation, for the full thickness of the sediments in the southern part of the Coastal Plain has not been determined. The oldest formations outcrop along the northern border of the Coastal Plain and dip southward, passing beneath the outcropping edges of successively younger formations. The maximum dip of the Cretaceous beds is probably 40 feet to the mile; their minimum dip is almost horizontal. The dip of the lower Eocene beds is from a few feet to probably 30 feet to the mile; and the dips of the succeeding formations up to the Alum Bluff are still flatter, ranging from a few feet to perhaps 15 feet to the mile. The Alum Bluff formation dips very gently southeastward and southward and is probably almost horizontal near the Florida line. The Miocene beds, so far as known, are likewise almost horizontal. The Pleistocene deposits mantle the older formations and conform to the general inclination of the plain.

Local displacements.—The strata of the Coastal Plain exhibit no great structural disturbances. Local disturbances of Cretaceous and Eocene beds have been noted along Chattahoochee River, and displacements of beds at other localities have been observed. None, however, are believed to be of magnitude, and all are probably the results of simple unimportant oscillations. These structural features can not be determined from the strike of the strata nor from the dips as seen in the outcrops, for those dips are in general so low that the strata appear almost horizontal. However, other lines of evidence are available.

Chattahoochee anticline.—The nature of the drainage, together with certain geologic facts, suggests that Chattahoochee River occupies the crest of a southward pitching low anticline. The stream has held its course and cut its channel down through the rising strata and belongs, therefore, to the class of antecedent streams. (See fig. 2.) The course of the Chattahoochee is almost directly southward in contrast to the southeastward courses of the other major streams—the Altamaha, Ocmulgee, Oconee, Ogeechee, and Savannah. Flint River flows west of south and is apparently located in a broad shallow syncline complementary to the Chattahoochee anticline. From west of Cordele to its junction with the Chattahoochee, Flint River is clearly a subsequent stream. The river flows along the southeastern border of its valley at the foot of a bajada. The low relief of the valley has been produced, not by the synclinal depression, but mainly by the removal in solution of the materials composing the limestones of the Chattahoochee and Vicksburg formations. The drainage divides of Chattahoochee and Flint rivers are strikingly unequal. (See Pl. III.) The tributaries of the Flint are much longer, notwithstanding that the Chattahoochee is much the larger stream. The interpretation is that the Flint River tributaries have been

centuated, at least in part, by the slope of the eastern limb of an nticline, whereas the Chattahoochee tributaries have developed nder the adverse conditions present on the crest of an anticline. That there have been greater upward earth movements along the Chattahoochee than along the other rivers is indicated by the much greater depth of the Chattahoochee Valley and by the deep trench-like channels which the main river and its tributaries have cut in the latest Pleistocene plain. The depth of these channels is 40 to 60

FIGURE 2.—Sketch map of the Coastal Plain of Georgia showing the relation of the drainage to the geologic structure.

feet on the Chattahoochee and not more than 15 to 40 feet on other large rivers. The Chattahoochee is now probably deepening its channel, for it has developed little or no flood plain along its course.

Geologic evidence of an anticline is afforded by the greater erosion and consequent exposure of the geologic formations along the Chattahoochee. The river has been able to cut into the older formations revealing them with greater perfection than along any other Coastal Plain stream, probably by reason of the upward earth movements which have accelerated downward cutting. For example, the intercept of the Chattahoochee water level with the Vicksburg formation is about 50 miles farther south than the intercept on the Flint. The Vicksburg formation, however, closely parallels the river as far nor

as Fort Gaines, suggesting that a great width has been completely removed by erosion. Fort Gaines would probably have been near the intercept had the same strike of the formations prevailed in Georgia as in Alabama, and had there been no greater uplift along the Chattahoochee than along the Flint. Greater local disturbances of strata have been observed along the Chattahoochee than in other parts of the Coastal Plain, and this may be considered evidence of a general and greater earth movement.

Withlacoochee anticline.—Physiographic and geologic evidence exists of a low fold or arch in the Oligocene strata in the area drained by Ochlockonee, Withlacoochee, and Alapaha rivers and extending along the Florida line from Decatur to Echols county and northward to Crisp and Wilcox counties. (See fig. 2, p. 58.) The limestones of the Chattahoochee formation appear in surface exposures in Lowndes, Brooks, Thomas, and Grady counties. This may be considered good evidence of an uplift, since, had the usual southeastward dip of the strata prevailed, the Chattahoochee formation would have been buried by later formations, as in the eastern part of the Coastal Plain. This arch is known as the Withlacoochee anticline.

This broad arch or fold was formed subsequent to the deposition of the Alum Bluff formation, and may have been involved in the orogenic movement which produced the Chattahoochee anticline.

In the area involved in this arching the rivers flow southward and appear to have had their courses determined by the original slope of the Coastal Plain, the normal direction of which is southward toward the Gulf of Mexico. In this respect these streams are in contrast to the streams of the Georgia Coastal Plain entering the Atlantic Ocean, nearly all of which have general southeasterly courses.

Alapaha River, the most easterly of the streams traversing the Withlacoochee anticline, is almost devoid of tributaries on its eastern side, and the divide separating its valley from the headwaters of Satilla River and the streams entering Okefenokee Swamp lies only a few miles east of the main river channel. To what extent this and other drainage peculiarities of the area have been produced by the arching has not been determined.

Monocline in eastern Georgia.—The southeastward courses of the Satilla, Altamaha, Ocmulgee, Oconee, Ohoopee, Ogeechee, Savannah, and other streams suggest that the eastern half of the Coastal Plain of Georgia is a monocline having a general southeastward pitch, and the dip and strike of the geologic formations afford conclusive proof of the existence of such a structure.

CRETACEOUS SYSTEM.

The Cretaceous deposits of Georgia include representatives of both the Lower and Upper Cretaceous series, which, in this report, are divided as follows:

Upper Cretaceous:
- Ripley formation:
  - Providence sand member. (A shallow-water phase of the formation.)
  - Marine beds.
  - Cusseta sand member. (A shallow-water phase of the formation.)
- Eutaw formation:
  - Tombigbee sand member. (Massive, glauconitic, and calcareous marine sands, forming the upper part of the formation.)
  - Sands, clays, and marls, chiefly of marine origin.

Unconformity.

Lower Cretaceous. Arkosic sands and clays. Not differentiated.

LOWER CRETACEOUS SERIES.

Areal distribution.—The Lower Cretaceous deposits appear in surface outcrops in Georgia in an extremely irregular belt, 2 to 30 miles in width, extending entirely across the State from Chattahoochee River, in the vicinity of Columbus, northeastward to Savannah River, in the vicinity of Augusta. The irregularities of the belt are due partly to the unevenness of the surface of the basement rocks upon which the deposits rest, partly to overlaps of younger formations, and partly to the deep erosion valleys which the streams have developed along the fall line and which cause the underlying basement rocks and the Lower Cretaceous deposits to appear successively much farther southward beneath the younger formations, than they would have appeared on the early uneroded surface. This irregularity is most strikingly developed in the region between Ocmulgee and Savannah rivers. (See geologic map, Pl. III.) The area in which Lower Cretaceous strata appear includes parts of Muscogee, Chattahoochee, Talbot, Marion, Taylor, Crawford, Bibb, Twiggs, Jones, Wilkinson, Baldwin, Washington, Hancock, Warren, Glascock, Jefferson, McDuffie, Columbia, and Richmond counties.

Stratigraphic position.—The Lower Cretaceous deposits in Georgia rest unconformably upon a basement of ancient crystalline rocks, which are believed to be of pre-Cambrian age. The unconformity represents an enormous time interval, including all Paleozoic time and the Triassic and Jurassic periods of Mesozoic time. The surface of the crystalline rocks is very uneven in detail but, in general, slopes south and southeast beneath the Lower Cretaceous deposits. Calculations from well borings at several places have shown that the slope in the region of the fall line is 30 to 75 feet to the mile. In Jefferson County a slope of between 35 and 40 feet to the mile is maintained for nearly 40 miles from the border of the Piedmont Plateau.

A. THOMAS BLUFF, CHATTAHOOCHEE RIVER, SHOWING LOWER CRETACEOUS STRATA.

View taken 1 mile below the mouth of Bull Creek, Muscogee County.

B. CUT ON THE COLUMBUS-MACON ROAD, 3½ MILES NORTHEAST OF COLUMBUS, MUSCOGEE COUNTY, SHOWING INDURATED LAYER OF LOWER CRETACEOUS ARKOSE.

Strike, dip, and thickness.—The strike of the Lower Cretaceous strata in Georgia ranges from N. 65° E., northeast of Macon, to nearly due east on Chattahoochee River at Columbus. The dip is east of south or south at right angles to the strike. On account of irregularity of bedding and the smallness of the exposures the exact amount of dip can not readily be determined. It is greater, however, than the grade of the water surface in the streams and probably averages 25 to 30 feet to the mile.

In the Chattahoochee region the estimated thickness of the Lower Cretaceous deposits where they pass beneath the overlying Eutaw formation is 375 feet. Calculations based on well data show that across the State along the line where the strata pass beneath the overlying Upper Cretaceous or Eocene formations, as the case may be, the total thickness of the deposits ranges from 350 to 600 feet, with perhaps local exceptions where the amount is less or greater.

The Lower Cretaceous deposits extend coastward beneath the unconformably overlying younger formations for at least 10 miles and probably for many more; their limit in that direction is not known.

UPPER CRETACEOUS SERIES.

EUTAW FORMATION.

Areal distribution.—The Eutaw formation appears at the surface in a relatively small area in Georgia. Chattahoochee River cuts across the outcrop, exposing the beds from a point a short distance below the mouth of Upatoi Creek, 9 miles below Columbus, to a point near Omaha, 2 or 3 miles below the Seaboard Air Line Railway bridge (see Pls. VI, *A* and *B*, and Pl. VII, *A*), a total distance of about 16 miles. To the northeast, away from the river, the area of outcrop becomes narrower, including approximately the northeastern two-thirds of Chattahoochee County, a small portion of southwestern Muscogee County, a strip several miles wide in the northern part of Marion County, and a very small portion of west-central Taylor County, ending in the western part of Taylor County.

Stratigraphic position.—The formation in Georgia rests unconformably upon strata of Lower Cretaceous age and is conformably overlain by the Ripley formation. In limited areas bordering Chattahoochee River and Upatoi Creek the formation is unconformably overlain by thin terrace deposits of Pleistocene age.

Lithologic character.—The materials composing the Eutaw formation vary considerably in lithologic character, both vertically and horizontally. In the region of Chattahoochee River the immediate base of the formation consists of coarse, arkosic, micaceous sands bearing a close resemblance to the underlying Lower Cretaceous sands. Interbedded with these sands are subordinate lenses of drab

A. BANK OF CHATTAHOOCHEE RIVER AT BROKEN ARROW BEND, 10½ MILES BELOW COLUMBUS, SHOWING LAYERS OF NODULAR, CALCAREOUS CONCRETIONS IN THE BASAL MARINE BEDS OF THE EUTAW FORMATION.

B. BLUFF BELOW BANKS LANDING, CHATTAHOOCHEE RIVER, LEFT BANK, 26½ MILES BELOW COLUMBUS, SHOWING GRAY CALCAREOUS SANDS AND SANDY CLAYS WITH INDURATED LAYERS BELONGING TO THE TOMBIGBEE SAND MEMBER OF THE EUTAW FORMATION.

A. SLICK BLUFF, CHATTAHOOCHEE RIVER, RIGHT BANK, 14 MILES BELOW COLUMBUS, SHOWING GREENISH-GRAY CLAY OF THE EUTAW FORMATION.

B. CUT ON COLUMBUS-LUMPKIN ROAD, 13 MILES SOUTH OF COLUMBUS, IN CHATTAHOOCHEE COUNTY, SHOWING UNCONSOLIDATED SAND OF THE EUTAW FORMATION.

to black laminated clay, in places bearing leaf remains and considerable though scattered quantities of lignite in the form of comminuted particles, twigs, branches, and logs.

Immediately above the coarse basal sands are 50 feet or more of medium to fine, gray to dark-gray, more or less micaceous and calcareous sands and clays, indurated in some layers to nodular impure limestones. (See Pl. VI, *A* and *B*.) These materials are fossiliferous and in places contain large numbers of shells and shell prints. The character of the materials and the nature of the entombed organisms prove this portion of the formation to be of marine origin.

The bluffs along the Euchee Rapids, Chattahoochee River, reveal 40 feet or more of greenish-gray, compact, marine clay, which lies closely above the marine sands and clays just described. (See Pl. VII, *A*.) This clay is overlain by dark, laminated clays with thin, interbedded layers of sand. Above the laminated beds are coarse and fine sands locally indurated to ferruginous sandstones, examples of which may be seen at Moores, Betons, and Codys rocks, between Euchee Creek and Chimney Bluff. A massive bed of fine to medium grained unconsolidated sand that probably represents this portion of the formation in Chattahoochee County east of the river is shown in Plate VII, *B*. Dark lignitic clays and light to white unconsolidated sands of shallow-water origin overlie the coarse sands, being best exhibited in the basal part of the exposure at Chimney Bluff, where the clays contain poorly preserved leaf remains.

Above the lignitic beds and forming the upper 120 feet of the formation are beds of massive gray or greenish-gray calcareous and more or less argillaceous sand, with some interbedded layers of gray calcareous sandy clay. (See Pl. VI, *B*.) These sands are more or less glauconitic and micaceous, and iron pyrites is fairly common. Nodular layers of sandy limestone and calcareous sandstone appear at vertical intervals of several feet as prominent projecting ledges along the faces of the bluffs. Fossils are common and certain layers contain shells in great abundance, forming shell marls. These massive marine sands and clays constitute the Tombigbee sand member of the Eutaw formation.

Northeastward from Chattahoochee River, in Chattahoochee and Marion counties, the massive marine beds, including the Tombigbee sand member, eventually merge into much coarser and more irregularly bedded deposits which doubtless originated near shore in shallow water or even in sounds and estuaries. Here, on account of similarity of materials, the formation is separable with difficulty from the overlying Ripley formation.

The irregularly bedded loose sands of shallow-water origin, which make up a considerable part of the formation, are favorable in extent and in texture to the circulation and storage of fairly large quantities

of potable though somewhat mineralized waters. The availabil
of this formation as a source of water supply is discussed more fu
on page 125.

Strike, dip, and thickness.—On the Georgia side of Chattahooc
River the beds of this formation strike N. 60°–75° E.; on the A
bama side they strike nearly east and west.

The Tombigbee member, which forms the upper part of the forn
tion, is regularly bedded and dips approximately 20 feet to the m
as estimated from exposures along Chattahoochee River. T
remainder of the formation, beneath the Tombigbee member, is irr
ularly bedded, and it has not been possible to make reliable
measurements; however, it is probably safe to infer that in no p
of the formation does the dip exceed 40 feet to the mile.

The total thickness of the formation has been estimated to
approximately 550 feet.

RIPLEY FORMATION.

Areal distribution.—The Ripley formation appears at low-wa
level in the bluffs of Chattahoochee River from a point about
miles below Columbus, near Florence, Ga., to a point, not accura
determined, near Othos Landing, about 15 miles below Eufaula,
It extends northeastward from the river in a belt 8 to 15 miles
that includes parts of Clay, Quitman, Stewart, Webster, Cha
hoochee, Marion, Schley, Macon, Taylor, Crawford, Houston,
Twiggs counties. In Twiggs, Houston, southeastern Crawford,
eastern Macon counties the formation is concealed by a relati
thin blanket of overlapping Eocene strata, except where the la
have been removed by stream erosion.

Stratigraphic position.—In western Georgia the formation is
formable with the underlying Eutaw formation. To the north
however, from the eastern part of Taylor County, through Cra
and Bibb counties to Ocmulgee River, the Eutaw formation,
in the Chattahoochee region intervenes between the Lower Creta
deposits and the Ripley formation, is believed to be absent, a
Ripley strata rest directly upon the Lower Cretaceous deposit
Macon, Crawford, Houston, and Twiggs counties the formati
concealed over a considerable part of the area, in which it
otherwise appear at the surface, by a thin overlap of Eocene
from the south; in Twiggs County, east of Ocmulgee River, the f
tion passes finally beneath overlapping Eocene beds.

Thin terrace deposits of Pleistocene age rest upon the beds
formation in small areas bordering Chattahoochee, Flint, and
gee rivers.

Lithologic character.—The exposures of the Ripley formatio
bluffs of Chattahoochee River, except, possibly, those in th

A. NARROWS OF PATAULA CREEK, 9 MILES NORTH OF FORT GAINES, SHOWING CALCAREOUS MARINE SAND OF THE RIPLEY FORMATION CONTAINING INDURATED LAYERS.

B. WATERFALL AT UPPER END OF NARROWS OF PATAULA CREEK.

Falls are produced by a hard calcareous layer.

A. CUT ON SEABOARD AIR LINE RAILWAY AT MANTA STATION, SHOWING CUSSETA SAND MEMBER OF THE RIPLEY FORMATION OVERLAIN BY TYPICAL MARINE BEDS OF THAT FORMATION.

B. GULLY 10½ MILES NORTHEAST OF GEORGETOWN, SHOWING COARSE, UNCONSOLIDATE SANDS OF THE PROVIDENCE SAND MEMBER OF THE RIPLEY FORMATION.

part of the high hill at Blufftown in Stewart County and the upper part of Stewarts Hill in Quitman County, all reveal materials of a strictly marine character. These are gray, calcareous, massive sands and clays of moderately deep-water, offshore origin, with interbedded darker clays and unconsolidated, yellowish, calcareous sands and shell marls of near-shore, shallow, marine origin. Typical marine strata of the formation are shown in Plate VIII, *A* and *B*. The shallow-water phases contain in places fragmentary bones of dinosaurs, mososaurs, crocodiles, and turtles, some reptile teeth, numerous sharks' teeth of several species, and a few other fish teeth. In the exposures at Woolridge Landing and vicinity these vertebrate remains are closely associated with an undescribed species of gigantic oyster and with a large number of other species of mollusks.

Northeastward from Chattahoochee River the basal 200 or 300 feet of the formation merges along the strike into shallow water equivalents (the Cusseta sand member), which differ in their essential lithologic characters from the typical beds. The uppermost 130 feet or more of the formation also merges along the strike, both to the northeast in Georgia and to the west in Alabama, into similar shallow-water equivalents (the Providence sand member).

The Cusseta sand member consists of irregularly bedded, unconsolidated sands with subordinate lenses of clay, of shallow-water origin. (See Pl. IX, *A*.) The member outcrops at the surface in a belt which includes parts of Stewart, Chattahoochee, Marion, Schley, Taylor, Macon, Crawford, Houston, Bibb, and Twiggs counties. In Stewart and Chattahoochee counties the sands vary from fine to coarse in texture and are somewhat arkosic. Farther northeast, in Marion County, the materials become coarser, although rather fine phases are not uncommon. This same predominance of coarse materials holds throughout the remainder of the outcrop, but, as in Marion County, finer sands occur locally. The clay lenses in these sands are commonly light drab or even white, are massive, and in places resemble the clays of the Lower Cretaceous. Locally they are thinly laminated. At a few places carbonaceous clays, both massive and laminated, containing considerable amounts of comminuted plant remains, have been noted, and fossil leaves have been collected at two localities. The similarity of the materials of the Cusseta sand member to the materials of the shallow-water phase of the Eutaw formation, in its eastern extension, renders the two formations separable with difficulty. The same is true of the Cusseta and the overlying Providence sand members in the region between Flint and Ocmulgee rivers.

The Providence sand member consists predominantly of coarse, irregularly bedded sands with subordinate, light-colored clays in the

form of lenses and layers. (See Pl. IX, *B*.) In Georgia the member outcrops in a long, narrow belt lying along the southern border of the Cretaceous area in parts of Quitman, Stewart, Webster, Marion, Schley, Macon, Houston, and Twiggs counties. The sands are commonly coarse but contain finer phases, especially toward the base of the member in the zone of transition from the underlying typical marine beds to the overlying coarser beds of the member. Rolled clay balls are numerous at many places in the sands. In Houston County the member contains notable lenses of white clay, which have been mined in a small way and which give promise of becoming of commercial importance in the future.

The typical marine beds, the "Renfroes marl" of Veatch, which intervene between the Cusseta and Providence members, are traceable in a narrow belt from the Chattahoochee region through Stewart, Chattahoochee, Marion, and Schley counties to Macon County, where they appear to pinch out, so far as can be determined from surface outcrops between the underlying and overlying shallow-water members. Beyond this point to the eastern limit of the surface occurrence of the formation the two members, each of which has gradually increased its thickness, are in conformable contact with each other and together appear to represent the whole thickness of the formation. However, there is evidence that buried representatives of the typical marine beds extend eastward at least as far as Marshallville, where calcareous beds have been penetrated in a well boring.

Both the Cusseta and Providence sand members are favorable in texture and structure to the circulation and storage of large quantities of potable waters. The typical marine beds are less favorable, although they too have yielded fair supplies at certain places. The availability of this formation as a source of water supply is discussed more fully on pages 125–126.

Strike, dip, and thickness.—The beds of the Ripley formation in the greater part of Georgia strike N. 60°–70° E., but in the area west of Chattahoochee River they strike nearly east. The estimated thickness of the formation, where it intercepts Chattahoochee River, is approximately 950 feet. No reliable measurements of thickness elsewhere in Georgia have been obtained, but there is reason to believe that a comparable thickness exists both to the northeast along the belt of outcrop and to the southeast in the buried extension of the formation.

TERTIARY SYSTEM.

EOCENE SERIES.

MIDWAY FORMATION.

Areal distribution.—The Midway formation outcrops in a relatively narrow northeast-southwest belt, extending from Fort Gaines on Chattahoochee River to Montezuma on Flint River and thence for a short distance into Houston County. On the Chattahoochee the formation has a width of about 8 miles, on the Flint a width of about 15 miles, and between the two rivers an average width of 8 to 10 miles. The formation appears at the surface over parts of Clay, Quitman, Stewart, Randolph, Marion, Schley, Webster, and Macon counties and extends eastward from Flint River probably as far as Myrtle on the Perry branch of the Central of Georgia Railway in Houston County. No occurrence is known east of Ocmulgee River, beyond which the formation is probably overlapped by higher Eocene formations.

Stratigraphic position.—The Midway formation rests unconformably upon the Upper Cretaceous. Irregular contacts that appear to represent erosion unconformities between the two divisions have been noted, especially in the gullies north and west of Lumpkin, Stewart County. The strata of the basal Midway and of the Upper Cretaceous seem to be lithologically similar, and on account of inadequate exposures considerable difficulty is experienced in determining the exact location and nature of the contact.

A probable contact between the Cretaceous and the Eocene is exposed in the first railroad cut east of the depot at Lumpkin, where the base of the Eocene consists of 4 to 6 feet of iron-stained clay containing ferruginous sandy layers bearing poorly preserved fossils, resting upon light-colored sandy clay of probable Cretaceous age. The evidence of an unconformity is, however, slight. Another probable unconformity has been noted about 1½ miles south of Lumpkin on the Cuthbert public road, where a ferruginous sand is separated from a kaolinic sand by a line of pebbles and is nearly approached on the south by apparent Eocene strata.

In Marion, Schley, and Macon counties the Midway formation lies in contact with the Upper Cretaceous, but the two closely resemble each other in lithologic character, and in mapping it is not possible to draw a sharp line between them. The Midway formation consists mainly of unconsolidated red, purplish, and white sands in which thin, siliceous limonitic layers and crusts and highly ferruginous sandstones are common. Thin beds of impure clay also occur, but neither the clays nor the ferruginous sandstones contain well-preserved fossils.

A probable contact between the Upper Cretaceous and the Midway formation occurs in a cut of the Central of Georgia Railway, a mile east of Buena Vista, the two divisions being separated by thin limonitic layers embedded in a stained clay. The lower part of the section is white or light-colored sand and sandy clay (Cretaceous), and the upper part, probably representing the Eocene, is a bright-red ferruginous sand.

At Underwood Ferry, on Flint River, 6 miles southwest of Marshallville, Macon County, the base of the bluff consists of gray or yellow rather compact argillaceous sand containing poorly preserved fossils. From this locality a specimen of *Venericardia planicosta* was obtained and on the basis of this fossil the strata are classed as Eocene. This is evidently near the northern margin of the Eocene, but its relations to the Cretaceous in this vicinity are obscure. It is also not positively known whether this sand represents the Midway or the Wilcox formation.

A gray and black laminated sandy clay bearing *Venericardia planicosta* was also discovered at Barrows Mill in Houston County, 5 miles east of Marshallville, where a poorly exposed unconformity may represent a Cretaceous-Eocene contact. *Venericardia planicosta* and *Turritella humerosa* were obtained in a similar sandy clay on Robert Slappy's land, 4 miles east of Marshallville, but the fossils are inadequate for determining whether the exposure is Midway or Wilcox.

No good physical evidence of an unconformity representing a considerable time interval between the Cretaceous and Midway has yet been discovered in Georgia, but there is paleontologic evidence that this interval is as great here as in adjoining States.

At Fort Gaines the Midway is separated from the overlying Wilcox by a pronounced unconformity.

Surficial gray and brownish sand is spread over the formation in places and Pleistocene terrace deposits overlie it along Chattahoochee and Flint rivers.

Lithologic character.—The Midway is mainly a marine formation of sands, clays, marls, and limestones. Its lower part consists principally of sands and clays, and its upper part of marls, clays, and limestones, but the sediments are so varied in character that sharp division lines can not be drawn on the basis of lithology. Thin layers of flint interbedded with sands and clays have been noted in the lower part of the formation. The sands are varicolored, generally friable, and in several places contain lenticular, massive layers of white clay. In the lower part of the formation limonite is rather widely distributed in the sands in the form of thin crusts and as hollow concretions having black, polished, and botryoidal exteriors. The limestones are fossiliferous—more abundantly so than other parts of the formation.

They are very hard and are generally highly arenaceous, though at a few places sufficiently pure for use in the manufacture of lime. They are conspicuous at several localities. Individual beds of limestone in natural exposures are thin, from 2 to 25 feet in thickness, and are interbedded with clays, marls, and sands. Friable marls made up of glauconite, quartz sand, clay, and shells occur, as do also laminated black clay and fuller's earth. Sands and clays make up by far the greater part of the deposits. The lithologic character and the character of the fossils indicate a very shallow water deposition for the whole formation.

Thickness.—The thickness of the Midway formation (referred by Langdon to the Clayton limestone of the Midway group, as used in Alabama) on Chattahoochee River was estimated by Langdon [1] to be 218 feet. The width of the outcrop on the Chattahoochee is about 8 miles, and it is believed that Langdon's estimate is nearly correct, though probably too large rather than too small. The thickness of the formation probably increases to the northeast and may reach 400 feet on Flint River, where the width of outcrop is about 15 miles.

Paleontologic character.—The collections of fossils from the formation are rather meager. This is due to a paucity of fossils in the exposed beds of the formation rather than to insufficient field work, for all the best-known exposures have been visited. *Ostrea crenulimarginata* seems to be a characteristic species, being found at nearly every outcrop of limestone and marl. The basal part of the formation, which consists mainly of sands and clays, is very poor in fossils. *Venericardia planicosta*, Turritella, and other forms occur, but these are common to other Eocene formations. One of the characteristic fossils of the formation in Alabama, *Enclimatoceras ulrichi*, has not thus far been found in Georgia. The following is a complete list of the forms identified:

Turritella mortoni Conrad.
Turritella humerosa Conrad.
Mesalia alabamiensis (Whitfield).
Arca sp.
Ostrea crenulimarginata Gabb.
Ostrea pulaskensis Harris.
Lithodomus gainesensis Harris.
Crassatellites.
Venericardia planicosta Lamarck.
Venericardia smithii Aldrich.
Cardium sp.
Protocardia sp.
Cytherea ripleyana (Gabb).

The determinations are by T. W. Vaughan from collections made by Veatch, McCallie, and Stephenson.

Physiographic expression.—The topography of the area underlain by the Midway is broken and hilly, somewhat resembling the Cretaceous area to the northward, and contrasting with the level topography of the areas to the south underlain by Claiborne, Jackson, and

[1] Langdon, D. W., Geology of the Coastal Plain: Alabama Geol. Survey, p. 369, 1894.

Oligocene strata. A few lime sinks occur in the vicinity of Fort Gaines and north of Cuthbert.

Structure.—The Midway formation presents no notable structural features. It strikes about N. 60° E. and dips gently east of south in conformity with the inclination of the older formations of the Coastal Plain, but its inclination can not be determined accurately on account of the discontinuity of exposures of individual beds and the wide variations due to local disturbances. As a whole the dip is roughly estimated at 20 to 30 feet per mile. This rate, however, is probably not maintained southward under cover of later formations, for a fossil, apparently the Cretaceous *Exogyra costata*, was found in the borings of an artesian well at Albany at a depth of 500–510 feet. (See p. 236.) Local crumpling of clay beds and very high local angles of dip, especially in Stewart, Randolph, and Quitman counties, may be the results of the movements that produced the Chattahoochee anticline.

WILCOX FORMATION.

Areal distribution.—The Wilcox formation outcrops in a belt extending northeastward from the vicinity of Fort Gaines on Chattahoochee River probably to Flint River in the northeastern part of Sumter County; east of the Flint it has not been certainly recognized. The width of the outcrop is believed to average not more than 5 or 6 miles. The formation is to some extent overlapped and obscured by the McBean and Vicksburg formations.

Stratigraphic position.—The Wilcox formation includes the strata lying between the Midway formation and the Claiborne group. At Fort Gaines, on Chattahoochee River, the Wilcox and Midway formations are separated by a pronounced erosion unconformity manifested by large holes, 20 feet or more deep, which have been worn in the white limestone of the Midway formation and filled by black sandy clay of the overlying formation. In the same locality paleontologic and lithologic differences also serve to separate the two formations. East of this locality, however, the paucity of the fossils, the fact that no unconformity could be discovered, and the unsatisfactory character of the evidence furnished by the lithologic composition, has rendered the discrimination of the two formations very difficult, and has made the mapping of the boundary line necessarily tentative.

The contact of the Wilcox with the overlying Claiborne group, where observed, is marked by an undulating line of small pebbles or a stratum of coarse sand but shows no physical evidence of the lapse of any considerable time interval between the deposition of the two. An unconformity marking the contact between the Claiborne group and the Wilcox formation has been noted, questionably in the bluff at Fort Gaines, 50 to 55 feet above Chattahoochee River; in a cut of the Central of Georgia Railway 2½ miles west of Cuthbert; at Halls

Bridge on Kinchafoonee Creek, 7 miles southwest of Plains; doubtfully in the public road at Blacks Mills 5 miles north of Plains; and 1½ miles southeast of Andersonville, on the south side of Sweetwater Creek, about a mile below Hodges Mill. Unfortunately, the strata are not fossiliferous, except at Fort Gaines, and the evidence that the unconformities are of stratigraphic importance is not entirely conclusive.

Lithologic character.—On Chattahoochee River the formation is made up of sandy glauconitic shell marl, dark-colored laminated, largely lignitic sandy clay, in places consolidated into mudstone, and commonly dark or gray glauconitic and lignitic sand. The laminated clay exposed in the bluff at Fort Gaines can be traced northeastward, and in Randolph County north and west of Cuthbert has the nature of fuller's earth, in places glauconitic. At Greer Cave a considerable thickness of varicolored and kaolinic sand apparently lies between the clay of the Wilcox formation and the limestone of the Midway formation. Black and drab laminated glauconitic clay and sand were observed on Bear Creek northeast of Weston, Webster County. Gray and black argillaceous and glauconitic sand appears at Magnolia Spring, 2½ miles north of Plains; in the bed of a branch on the old Morgan plantation, 6 miles northeast of Plains; and at Halls Bridge, on Kinchafoonee Creek 7 miles southwest of Plains. Farther east in Schley and Macon counties and in the vicinity of Andersonville, the strata which might be referred to this formation on the basis of geographic position are mainly red and varicolored sands with massive beds of white clay, very pure and in the nature of sedimentary kaolin, bearing little resemblance to the strata on Chattahoochee River.

Thickness.—Langdon [1] estimated the thickness of the formation on Chattahoochee River at 402 feet; but this is excessive, for at Fort Gaines the thickness is certainly not more than 60 or 75 feet. A natural exposure of the formation at Peterson Hill, 4½ miles northwest of Cuthbert, reveals about 100 feet of strata. The following is the record [2] of a well at Shellman, Randolph County:

Record of well at Shellman.

	Thickness.	Depth.
	Feet.	*Feet.*
Red clay	18	18
Quicksand	130	148
Blue marl	152	300
Very hard limestone	100	400
Water-bearing formation	10	410

[1] Langdon, D. W., loc. cit.

[2] McCallie, S. W., Underground waters of Georgia: Georgia Geol. Survey Bull. 15, p. 156, 1908.

If the limestone layer is the same as the limestone of the Midway formation exposed at Greer Cave, about 16 miles to the northwest, the overlying 152 feet of "blue marl" may belong to the Wilcox formation.

There is no positive proof that strata of Wilcox age outcrop on Flint River, where the formation may be entirely overlapped by the Claiborne group, but if the strata between the Midway and the McBean or Vicksburg formations at Dripping Bluff, 9 miles south of Oglethorpe, are Wilcox, the thickness of the latter is perhaps 100 feet. The maximum thickness at any place in the area of outcrop probably does not exceed 150 or 200 feet.

Paleontologic character.—The formation is poorly fossiliferous in Georgia. The following forms have been identified by T. W. Vaughan from collections made by Mr. Veatch east of Chattahoochee River:

Actæon.
Turritella mortoni Conrad.
Turritella præcincta Conrad.
Ostrea thirsæ (Gabb).
Venericardia planicosta Lamarck.
Cardium.
Calyptrea aperta (Solander).
Dentalium.
Leda pharcida Dall.
Glycymeris.
Protocardia.
Cytherea.
Cassidulus (?) sp.

The following fossils were obtained 5½ miles south of Lumpkin:

Endopachys maclurii (Lea).[1]
Pyrula juvenis Whitfield?
Turritella sp.
Leda (apparently pharcida Dall).
Cytherea nutalliopsis Heilprin?
Nucula sp.
Paracyathus? sp.
Cucullæa macrodonta Whitfield.
Cytherea sp.

The species *Ostrea thirsæ*, *O. compressirostra*, *Chlamys greggi*, and *Cucullæa macrodonta* have been identified from beds near Fort Gaines. From beds 4½ miles northeast of Preston and from a flint bed 1 mile south of Preston T. W. Vaughan has identified *O. thirsæ*, a small oyster considered characteristic of the Wilcox formation. As the collections are small and the material in general poorly preserved, the stratigraphic deductions from the fossils can not be made with the same surety for Georgia as for States to the west, where fossils are more abundant and better preserved. Possibly these beds belong to the Midway.

Physiographic expression.—The area underlain by the formation is small and presents no notable physiographic features. The topography of the area is rather broken and hilly, resembling that of the area to the north underlain by the Midway formation.

Structure.—The Midway strata strike about N. 55° E. and dip southeastward at a rate that can not be accurately estimated but that is probably less than 30 feet to the mile over the area of outcrop

[1] *Endopachys maclurii* suggests Claiborne, *Cucullæa macrodonta* is usually not later than Wilcox.—T. W. Vaughan.

and is perhaps less than half as much under cover of the later formations to the south. No evidence of local deformation has been noted, although such deformation may have taken place in the area adjacent to Chattahoochee River, where slight disturbances have been noted in the Midway formation.

CLAIBORNE GROUP.

SUBDIVISIONS.

The Claiborne group or, where the strata representing the group are not subdivided into constituent formations, the Claiborne formation derives its name from the old town of Claiborne, on Alabama River, Ala.

In Alabama the Claiborne group is subdivided, from the top downward, into the Gosport greensand, the Lisbon formation, and the Tallahatta buhrstone. Although in a general way the correlatives of these formations may be recognized in Georgia, the use of these terms in the latter State is inappropriate, for the Claiborne group is not naturally divisible into the same units as in Alabama. In Georgia the group is divided into two formations—the Barnwell sand at the top and the McBean formation at the base, the latter including a phase to which the name Congaree clay member has been given. It is, however, difficult to distinguish between the weathered phases of the McBean formation and the overlying Barnwell sand and no attempt has been made to map the two formations separately, the Claiborne group being given one color on the geologic map.

McBEAN FORMATION.

Areal distribution.—The McBean formation outcrops in an extremely irregular belt, which varies in width from a few miles to 25 or more and extends entirely across the State. Between Savannah and Ocmulgee rivers this belt lies south of the Lower Cretaceous outcrops, and between Ocmulgee and Chattahoochee rivers it lies south of the Midway and Wilcox outcrops. East of Flint River its exposures have been studied in Columbia, Richmond, Burke, McDuffie, Jefferson, Glascock, Washington, Baldwin, Wilkinson, Jones, Twiggs, Bibb, and Houston counties. Exposures occur also on Flint and Chattahoochee rivers. East of Ocmulgee River the group originally entirely concealed the Lower Cretaceous deposits and lapped over on the crystalline rocks of the Piedmont Plateau; but the region has since been extensively dissected by erosion and the crystalline rocks and Cretaceous strata are now exposed along the lower slopes and bottoms of the valleys; the northern boundary of the formation is therefore extremely irregular. South of the area of outcrop Claiborne group fossils, probably from the McBean formation, have been obtained between the depths 347 and 364.5 feet from a well at Herndon, Jenkins County. (See section, p. 293.)

Stratigraphic position.—East of Ocmulgee River the McBean formation rests unconformably upon strata of Lower Cretaceous age. The unconformity represents a long interval of time, for the two lower Eocene formations, the Wilcox and Midway, and all the Upper Cretaceous deposits, aggregating a thickness of 3,000 feet or more, are absent. Tongues of McBean strata extend northward on the divides across the Cretaceous rocks and in places lap over the crystalline rocks of the Piedmont Plateau. The most notable overlaps are at Roberts, Harlem, and Grovetown.

Between Flint and Chattahoochee rivers the McBean formation rests upon the Wilcox formation. Along Chattahoochee River, in the vicinity of Fort Gaines, an erosion unconformity, probably of minor time importance, seems to separate the Wilcox and the McBean formations.

The formation in eastern Georgia is overlain by the Barnwell sand, which in this region constitutes the upper formation of the Claiborne group. The relations between the two formations are somewhat obscure. Along its northern areal margin the Barnwell sand is apparently separated from the McBean formation by an unconformity of slight time importance, but farther southward it seems to rest conformably upon the McBean. It seems probable that near the end of the deposition of the McBean formation an uplift brought the northern margin of the area of Claiborne deposition above sea level, permitting erosion to take place in the emerged area, while deposition continued in the area which remained under water. The uplift was of short duration, however, the emerged tract soon being submerged again, allowing deposition to continue over the whole belt.

The Barnwell sand is believed to be present west of Flint River where its relations to the underlying McBean formation are doubtless the same as in the area east of the river.

Lithologic character.—The formation consists mainly of shells, marls, sandy limestones, calcareous, glauconitic sands and clays of the nature of fuller's earth. The marls are for the most part massive, bedded and friable, but hard, compact, and even partly siliceous beds have been noted on Savannah River. In places layers of marl and calcareous sand alternate with laminated clays. The greatest thickness of the marl beds is in the Savannah River bluffs at Shell Bluff, where a thickness of over 100 feet is exposed. (See Pl. X, *B*.)

The marls of the McBean formation reach their greatest development on Savannah River; they extend southward from Shell Bluff about 11 miles in a direct line to a point 1½ miles below Griffins Landing where they appear in the bluff 50 feet above the water level. Westward from Savannah River marls are exposed near McBean, Louisville, Tennille, Sandersville, and elsewhere.

A. EXPOSURE OF THE McBEAN FORMATION (CLAIBORNE GROUP) ON AN ISLAND AT THE MOUTH OF OMUSEE CREEK, CHATTAHOOCHEE RIVER, 2 MILES BELOW COLUMBIA, HOUSTON COUNTY, ALA.

B. PORTION OF OSTREA GEORGIANA BED OF THE McBEAN FORMATION DISPLACED BY LANDSLIDE AT SHELL BLUFF, SAVANNAH RIVER, BURKE COUNTY.

The strata between Flint and Chattahoochee rivers present a close general lithologic similarity to those of the eastern area. Along the northern margin of the formation, red, rather coarse sands at the surface overlie laminated or thin-bedded clays, while southward or seaward the beds are calcareous, and sandy marls, very similar to those along Savannah River, interbedded with clay, are overlain by red sand similar to the Barnwell sand. Flint is apparently absent, but there are some thin layers of sandstone or quartzite in the sand. Clay or fuller's earth is less extensively developed, but this phase is represented by drab, laminated, fossiliferous clays, such as occur at the base of the formation at Fort Gaines.

The Flint River exposures are friable calcareous sands, sandy limestones, marls, and sandstones. On Chattahoochee River Langdon recognized a lower buhrstone member and an upper calcareous member. Here as elsewhere the formation presents a variety of lithologic phases, including gray glauconitic limestones, marls resembling those on Savannah River, calcareous clays and claystones, and red and varicolored unconsolidated sands. (See Pl. X, *A*.)

Exposures of the formation are of small areal extent, and the marls and other materials have had but little effect on the soils of the region underlain by them.

The marls are commonly replete with fossils, the casts and shells of mollusca being the most common. Vertebrate remains (fish teeth and fragments of bones), Bryozoa, and corals have been collected.

A portion of the McBean formation consists principally of fuller's earth and drab or greenish sandy clays. This is a depositional phase of the terrane, and is best exposed along the northern margin of the formation, from Grovetown, Columbia County, to near Macon. This phase has been named the Congaree clay member of the McBean formation. (See p. 77.)

The McBean formation as a whole is marine in aspect and was doubtless deposited near shore in shallow water.

Thickness.—The thickness of the McBean formation east of Ocmulgee River is estimated to be 300 to 400 feet. The maximum exposed thickness occurs at Shell Bluff, Savannah River, where 115 feet of strata was measured. The thickness of the Claiborne group near Louisville, Jefferson County, estimated from the record of an oil-prospecting well, is 350 feet, the greater part of which is referable to this formation; however, the upper 68 feet may belong to the Barnwell sand. The lithologic character of borings obtained from a well at Waynesboro indicates that at that place the maximum thickness of the Claiborne group is not over 500 feet and may be less; all except about 100 feet of this is referable to the McBean formation. In parts of the area over which the McBean is the surface formation, the thickness will vary from 50 feet or less to 150 feet. The thickness along

Ocmulgee and Oconee rivers is certainly much less than that along Savannah River, a fact suggesting the existence of a structural basin in the Savannah area during the Claiborne epoch.

Between Ocmulgee and Chattahoochee rivers, where the Barnwell sand has not been certainly identified, the thickness of the Claiborne group seems to be less than in Burke County.

On Chattahoochee River the estimated thickness of the Claiborne group is 150 or 200 feet. On the Flint, judging from the width of the outcrop, the thickness is not greater than that on the Chattahoochee and is probably less. The thickness between these two rivers, as shown by natural exposures, is not greater than 150 or 200 feet.

Paleontologic character.—The most extensive collection from any single locality in the area underlain by this formation was made by Earle Sloan at Sloans Scarp on McBean Creek, between McBean station and Savannah River. Sloan submitted his fossils to T. W. Vaughan, who contributes the following notes:

> In Georgia the McBean formation includes two paleontologic horizons. The lower one is especially characterized by *Pleurotoma nodocarinata* Gabb, *Turritella nasuta* Gabb, *Turritella nasuta* var. *houstonia* Harris, *Ostrea sellæformis* Conrad, *Pteropsis lapidosa* Conrad, and *Corbula fossata* Meyer and Aldrich.
>
> A higher horizon is represented especially well along Savannah River between Shell Bluff upstream and Griffins Landing downstream. Along this stretch of the river a prominent ledge, largely composed of *Ostrea georgiana* Conrad, forms the top of the McBean formation. Although this formation could be subdivided along Savannah River it was found impracticable to extend the subdivision westward, for which reason the *Ostrea georgiana* bed is considered as constituting its upper portion.

Between Ocmulgee and Chattahoochee rivers exposures of strata belonging to the Claiborne group have been examined 4½ miles south of Perry, Houston County; along Flint River at several localities, notably at the old Danville Ferry and at Penny Bluff; and along Chattahoochee River for a considerable distance below Fort Gaines. Fair collections of fossils, obtained from a number of exposures, render it safe to state that the McBean formation extends uninterruptedly from the Savannah to the Chattahooche. However, the formation is masked at many places by later deposits ranging in age from Jackson and Vicksburg to perhaps Pleistocene. The red, rather coarse sands that underlie the Vicksburg and overlie the recognizable McBean may be the westward continuation of the Barnwell sand, but as no fossils have been obtained from the sands between Ocmulgee and Chattahoochee rivers positive correlation with the Barnwell sand of the Savannah drainage can not be made.

Physiographic expression.—Over practically the whole area of its occurrence east of Ocmulgee River the McBean formation is overlain by the Barnwell sand, appearing at the surface only in the stream bluffs and on the lower slopes and in the bottoms of the valleys. On account of the compactness of the materials composing it the for-

mation has been effective in places in preventing the rapid reduction of the valley sides from steep to gentle slopes, but otherwise it has had only a subordinate part in determining the topographic aspect of the region.

Structure.—The McBean formation as a whole has a low dip east of south, perhaps not more than 10 or 15 feet to the mile. The dip of individual beds is so slight that they appear horizontal in natural exposures. No pronounced folding or faulting has been observed. Langdon [1] noted low flexures along Chattahoochee River; but only purely local disturbances, such as might be due to land slips or weathering and solution of calcareous strata, were noted in the Ocmulgee-Savannah area. The thick beds of clay and fuller's earth show minute jointing. Clay laminæ show slight crumpling at a few localities, but this is of doubtful regional significance. An exposure of the McBean formation occurs 4½ miles south of Perry, Houston County, at an elevation higher than Jackson outcrops lying to the north. The structural relations are unexplained, but are probably due to folding or faulting.

Congaree clay member.—The Congaree clay member consists principally of fuller's earth and drab or greenish sandy clays. Its name is adopted from South Carolina, where Sloan [2] states its distribution as follows:

> The Congaree phase is abundantly exhibited in the western Tertiary division along a curved line extending by Aiken, Sandy Run (on the Congaree), Wedgefield, and thence down the eastern side of Santee River; it is also characteristically exhibited along the belt extending from Wedgefield toward the eastern division north of the Carolinian ridge. East of the latter the Congaree phase is probably exhibited in thin shales interlaminated with sands along the western bluffs of Peedee River.
>
> The Congaree phase exhibits its littoral line along Hollow Creek near Savannah River and proceeds with occasional tongues extended in conformity with the shore line indicated for the Tertiary. The main line proceeds from McBean Creek valley, Ga., by Beech Island, Aiken, Perry, Horseys Bridge, and Gaston, to the vicinity of Congaree Bluff.

The Congaree clay member of the McBean formation in Georgia lies at the base of the Claiborne group, resting directly upon the Lower Cretaceous, from which it is separated by a conspicuous erosion unconformity of regional extent. Striking differences in lithologic character and the character of the fossils in the Congaree clay afford an easy means of distinguishing it from the underlying beds.

Faunally, the Congaree clay member does not seem to differ from the lower faunal horizon of the marl of the McBean formation. It seems probable that the clays represent a shoreward phase, or that the Congaree clay member becomes more calcareous southward and gradually merges into the marl. In most of the sections studied the

[1] Langdon, D. W., Report on the Coastal Plain: Alabama Geol. Survey, p. 389, 1894.

[2] Catalogue of mineral localities of South Carolina: South Carolina Geol. Survey, pp. 454, 455, 1908.

clay and fuller's earth seem to pass by gradation upward into the Barnwell sand. Some unconformities and some abrupt changes in the character of the strata may be only such as are natural in shallow-water deposits.

The fuller's earth contained in the Congaree clay member is drab or gray (often olive-green when moist), fine grained, thinly bedded, and minutely jointed. (See Pl. XI, *A*.) Where pure it is soft, unctuous, and breaks with a smooth conchoidal fracture, but it is generally sandy and contains small sand lenses and pockets and thin micaceous sand partings. It is low in specific gravity and peculiar in physical properties, being highly porous, adhering strongly to the tongue, and, in thin pieces, being light enough to float on water.

At a few places the Congaree clay member contains a large amount of disseminated lignitic matter and thin beds of lignite, as at the lignite pit 3 miles south of Grovetown. Thin-bedded, shalelike, aluminous sandstones and dense vitreous quartzites were observed near the base of the member at Hephzibah, Wrens, Gibson, Chalker, and other localities. At a number of localities greenish or drab, stiff or tough clays, showing little or no lamination and attaining a thickness of 80 or 100 feet, lie in contact with the Lower Cretaceous. In places the materials consist of alternating layers, a few inches thick, of clay and varicolored sand.

The member reaches a thickness of at least 100 feet. Fossils are abundant at a few places, though on the whole the member is not as fossiliferous as the typical marls of the formation. The animal remains are mainly molluscan casts, although the clay also contains thin marly layers in which shells occur in quantity, and in which fish teeth and fragments of bones are found. Plant localities have been discovered at Grovetown, Hephzibah in Richmond County, and 10 miles south of Macon in Bibb County. This member is not paleontologically distinct from the McBean formation.

The Congaree clay member outcrops in numerous places from Grovetown southwestward along the fall line to Bibb and Twiggs counties. It is confined to the northern part of the area of outcrop of the McBean formation, but it can not be sharply separated from either the marls of the McBean formation to the south or from the overlying Barnwell sand. The most prominent and typical exposures are at Grovetown, Harlem, Gibson, Gordon, Roberts, and Pikes Peak in Twiggs County. The clays have had no marked influence on the soil and vegetation, outcropping mainly in gullies and ravines where the overlying red sands have been eroded.

A. CUT ON MACON, DUBLIN & SAVANNAH RAILROAD AT PIKES PEAK STATION, TWIGGS COUNTY, SHOWING THE CONGAREE CLAY MEMBER OF THE McBEAN FORMATION.

B. FLINT AND LIMESTONE OF THE VICKSBURG FORMATION JUST ABOVE DEWITT FERRY, FLINT RIVER, MITCHELL COUNTY.

BARNWELL SAND.

Areal distribution.—The Barnwell sand of the Claiborne group is practically coincident in its distribution with that of the Claiborne group as a whole. The formation overlies both the marls and the clays of the McBean formation and extends to the fall line, being present over parts of Columbia, Richmond, Burke, McDuffie, Jefferson, Glascock, Washington, Hancock, Wilkinson, Baldwin, Twiggs, Jones, and Bibb counties. No evidence was found indicating that the fossiliferous red sands in the southern part of the area are later in age than, or are superimposed upon, the sands which near the fall line overlie the Congaree clay member. It is probable that red sands overlying the McBean formation between Flint and Chattahoochee rivers belong to this formation, but no positive statement to this effect can yet be made. The conspicuous red soils of the Claiborne group are derived from the Barnwell sand.

The formation is particularly well developed in Burke County, where it contains fossiliferous flint and appears at the surface as a dark-red ferruginous sand. It is also well developed over other counties to the west.

Stratigraphic position.—The Barnwell sand directly overlies the McBean formation and is in contact with both the marls and the Congaree clay member of the latter formation. The nature of the contact separating the Barnwell sand from the McBean formation has not been satisfactorily determined; there is evidence, however, that along the northern margin of the Barnwell sand area the relation is that of unconformity, though of local, not of regional, extent. Farther southward the Barnwell sand seems to overlie the McBean formation conformably. The probable explanation of this discordance of relationship in different parts of the area is that after the deposition of the clays and marls of the McBean formation an uplift of the region caused the shore line of the Claiborne sea to recede southward a short distance and permitted erosion in the emerged area. Later, after a relatively short period, resubmergence permitted deposition to be resumed over the entire Claiborne area.

The Barnwell sand is overlain by the Jackson formation, but the contact between the two has nowhere been observed and its nature is imperfectly known. There is some evidence in favor of a faunal and lithologic gradation and, on the other hand, some suggestion of unconformity.

In Burke and Screven counties the formation is overlapped by the Vicksburg formation and questionably by the Chattahoochee formation and the typical Alum Bluff. In the eastern part of the State a large part of it was probably originally overlain by still later undifferentiated deposits, two prominent occurrences of which still extend northward to Tennille and Waynesboro. The Barnwell sand is in

places covered with a small thickness of surficial gray sand of problematic origin and by Pleistocene terrace deposits along the rivers.

Lithologic character.—The Barnwell sand consists largely of unconsolidated red and varicolored sands, embedded in which are also thin layers of sandstone, quartzite, silicified limestone or flint, and thin layers of siliceous limonite. The sands, especially where weathered, appear somewhat similar to the red, residual sands of the Vicksburg formation, with which they seem to be in contact in the southeastern part of Burke County, and from which, where fossils are absent, they can with difficulty be discriminated.

The flint and quartzite contain casts and siliceous replacements of fossils, and good collections have been obtained at several localities. The sand itself is poorly fossiliferous, containing only imperfect casts and molds of fossils and fragments of silicified wood.

Thickness.—The maximum measured thickness of the Barnwell sand is 105 feet, this thickness being observed on Storm Branch below Cox Spring, about 2 miles northeast of Shell Bluff post office.

Paleontologic character.—Among the common fossils of the Barnwell sand are Mortonia, *Mesalia vetusta* (Conrad), *Turritella carinata* Lea, *Glycymeris staminea* (Conrad), *Crassatellites protextus* var. *lepidus* Dall, *Venericardia alticostata* (Conrad), *Cytherea perovata* Conrad, and *Spisula prætenuis* (Conrad). The best collection of fossils from a single locality is that from Old Town, 7½ miles southeast of the present site of Louisville.

Physiographic expression.—The Barnwell sand has been an important factor in determining the topography. The greater part of its area is hilly and broken, for the friable sands and soft clays of the formation have yielded readily to erosion. In Twiggs, Wilkinson, and Washington counties valleys have been cut 150 to 200 feet below the level of the ridges and small plateaus, and at many places the hills are furrowed by deep gullies and ravines. In Burke and Jefferson counties there are flat plains in which lime sinks have resulted from the collapse of solution cavities in the underlying McBean formation.

Structure.—The bedding planes of the Barnwell sand have been largely obscured by chemical changes. For this reason it has been impossible to obtain accurate dip observations. However, the beds dip east of south at a rate probably not exceeding 10 or 15 feet to the mile.

JACKSON FORMATION.

Areal distribution.—The total area over which the Jackson formation outcrops in Georgia is, so far as known, small. The largest connected area is in Johnson, Wilkinson, Houston, Twiggs, Pulaski, Dooly, and Sumter counties. There is a small, isolated area at Rich

Hill, Crawford County, and, according to Langdon,[1] a small area on Chattahoochee River near Alaga, Ala. The strata exposed on Oconee River at Wring Jaw Landing, Johnson County, are referred to the Jackson formation by T. W. Vaughan. Further detailed work may reveal occurrences east of the Oconee. Between Flint and Chattahoochee rivers outcrops have been found only on Ichawaynochaway Creek, 1½ miles below Cordray mill, Calhoun County; if the formation outcrops elsewhere to any considerable extent it has not been distinguished from the strata of the Vicksburg formation and the Claiborne group. The Jackson formation has been recognized at Americus, Sumter County, where fossils obtained in a well boring seem to show that it extends from the surface to a depth of 157 feet. (See section, pp. 394–395.)

South and southeast of the areas of outcrop limestones, which probably include in ascending order the Jackson, Vicksburg, and Chattahoochee formations, have been more or less completely penetrated in numerous well borings. On the McArthur plantation in Montgomery County (p. 346), for instance, the limestones were penetrated from 350 to 890 feet, and at Bainbridge, Decatur County, to a depth of 825 feet (p. 220). At Doctortown, Wayne County, limestones with interbedded layers of sand were penetrated from 465 to 1,470 feet, but this thickness (1,005 feet) perhaps includes limestone beds referable to the Claiborne group, which underlies the Jackson formation. Similar limestones with interbedded layers of sand were penetrated at Savannah in the wells at the municipal water-supply plant from 250 to 500 feet.

Stratigraphic position.—The Jackson formation is the uppermost terrane of the Eocene of Georgia; stratigraphically it lies between the Claiborne group below and the Vicksburg formation above. The line of division between it and the Claiborne group has not been accurately determined, and it can not be stated with certainty whether or not deposition continued uninterruptedly from the one to the other, for the two formations are similar lithologically. According to the evidence of the fossils, beds referable to the Jackson formation occur near the mines of the Georgia Kaolin Co. in Twiggs County—an occurrence explainable only by faulting or folding or by an overlap and erosion unconformity. Paleontologic evidence also indicates that an unconformity may exist between the two formations south of Perry in Houston County, though none has thus far been observed in surface outcrops.

In Mississippi the Claiborne and Jackson seem to be closely related. Crider[2] states that "even where the formations have been best

[1] Report on the Coastal Plain of Alabama: Alabama Geol. Survey, p. 383, 1894.
[2] Crider, A. F., Geology and mineral resources of Mississippi: U. S. Geol. Survey Bull. 283, pp. 33, 34, 1906.

studied there seems to be a gradation in both the fossils and the stratigraphy from the upper Claiborne to the lower Jackson." In Alabama the Jackson has not been described as a separate formation, and very little specific information as to its relations with the Claiborne has been published. From the description in Langdon's report [1] on the geology of the Coastal Plain of Alabama it is evident that the two are closely related lithologically and faunally, and in sections where both are exposed no mention is made of unconformable relations.

Where the Jackson and the Vicksburg formations have been observed in the same section in Georgia there is no evidence of an unconformity or break in the vertical continuity of the strata.

The Jackson formation at Rich Hill, 5 miles southeast of Roberta, Crawford County, rests directly upon Lower Cretaceous strata, and the presence of marine deposits at this locality indicates that the formation originally extended as an overlap much farther northward than at present and suggests that it may have even transgressed upon the crystalline rocks of the Piedmont Plateau.

Lithologic character and thickness.—The formation consists of white or cream-colored, massive-bedded limestones, thin beds of marl, and calcareous, glauconitic, and sandy laminated clays. The limestones are highly fossiliferous, in places consisting almost entirely of a friable mass of Bryozoa and shells. Southward from Perry there is a considerable thickness of loose red and yellow quartz sand and clay, the stratigraphic position of which has not yet been fixed, but which may belong in part to the Jackson formation. Silicification of the limestone was noted half a mile north of Bonaire and also south of Perry, Houston County.

The thickness of the Jackson formation in the area of outcrop can not be determined with accuracy, mainly on account of uncertainty as to the location of the line of division between it and the Claiborne group. About 75 feet of it is exposed at Rich Hill, and about the same amount south of Perry, not including the sands underlying the fossiliferous strata. At Americus, Sumter County, the thickness as shown by a well record is 157 feet. The buried representatives of the formation in south-central Georgia probably exceed 100 feet in thickness.

Paleontologic character.—The limestones of the formation are highly fossiliferous, but the clays and sands are only sparingly so. As in Mississippi and Louisiana, the formation seems to mark the upper limit of *Venericardia planicosta*. In places Bryozoa make up the greater part of the rock, this being especially true of the occurrences at Rich Hill, Crawford County, at Ross Hill, 3¼ miles south of Perry, and at other localities. Of the 24 species which have been deter-

[1] Op. cit., pp. 111, 128, 381, 383.

mined from the Jackson formation in Georgia, only 6 are common to the overlying Vicksburg formation. The whalelike mammal, Zeuglodon (Basilosaurus), is a characteristic fossil of the Jackson, and some fragments of it have been found in Georgia. As in the Vicksburg formation, Pecten and Orbitoides are abundant; *Pecten perplanus*, *Pecten nuperus*, and *Orbitoides mantelli* appear in both formations.

Physiographic expression.—The limestone member of the formation has produced a prominent scarp on the south side of Indian and Mill creeks in Houston County. Rich Hill, in Crawford County, is a conspicuous topographic feature, owing to the fact that the limestones and clays of the formation resisted erosion better than the Cretaceous sands and clays. A few lime sinks occur north of Bonaire.

Structure.—The formation dips gently southeastward. Visual evidence of folding was not noted in field work, but either a fold or fault in the strata or an erosion unconformity between the Jackson formation and the Claiborne group must be assumed to explain the position of the McBean formation at a level stratigraphically higher than the Jackson 4½ miles south of Perry.

OLIGOCENE SERIES.

VICKSBURG FORMATION.

Areal distribution.—The Vicksburg formation outcrops over a large area in the western part of the Coastal Plain of Georgia, including parts or all of the counties of Sumter, Lee, Terrell, Webster, Randolph, Clay, Early, Calhoun, Dougherty, Baker, Mitchell, Miller, and Decatur. Areas of outcrop also occur in Crisp, Dooly, Houston, Pulaski, Twiggs, and Laurens counties. Eastward from Oconee River the formation has been largely concealed by later formations, and only small areas of it are known in Screven and Burke counties. With the exception of the undifferentiated and the Pleistocene surficial deposits, the area over which the Vicksburg is the surface formation is greater than that of any other formation of the Coastal Plain.

The formation has been recognized in well borings, on paleontologic evidence, southeast and south of the areas of outcrop at Claxton, Tattnall County, between the depths 365 and 550 feet (see log, p. 404); at Waycross, Ware County, between the depths 415 and 691 feet (see log, pp. 438–439); at Kingsland, Camden County, between the depths 450 and 482 feet (see p. 178); and at Valdosta, Lowndes County, between the depths 400 and 480 feet (see log, pp. 318–319).

Stratigraphic position.—The Vicksburg formation, which is classified as Oligocene, occupies a stratigraphic position between the Jackson formation (Eocene) below and the Chattahoochee formation above. Contacts with the Jackson formation were seen in Houston and Pulaski counties, where there seems to be no physical break between the two divisions.

West of Flint River the Vicksburg overlaps northward to the belts of outcrop of the Midway and Wilcox formations and has largely obscured the Claiborne group and the Jackson formation. Unconformable contacts with the Claiborne group, the Jackson apparently missing, were noted near Fort Gaines, Cuthbert, Shellman, and Andersonville.

Unconformable contacts between the Vicksburg formation and the overlying Chattahoochee formation have been observed in the vicinity of Bainbridge, Decatur County, by Pumpelly[1] and Vaughan.[2] (See Chattahoochee formation, pp. 86–89.) Northward from Decatur County, in the escarpment on the east side of Flint River, the upper part of the formation has been so much obscured by weathering that its relations to the overlying Chattahoochee formation can not be observed. Eastward in Dooly, Pulaski, Laurens, Burke, and Screven counties, and in other counties along the northern margin of the formation, the Vicksburg formation is overlapped and partly obscured by the Alum Bluff formation and by later deposits, so that here also its relation to the Chattahoochee formation can not be observed.

Lithologic character.—The formation is made up principally of limestones but also contains beds of sand and clay. The limestones have been extensively silicified and in many places do not appear at the surface, but are concealed by varicolored, very coarse grained, sandy clays, probably residual, in which residual flint fragments are embedded.

The limestones are generally white or cream-colored, soft, earthy, and very abundantly fossiliferous. In places flat, disklike Orbitoides, Bryozoa, and Pectens and their fragments form nearly the whole of the rock. Along Flint River the rock has a characteristic vesicular or pitted appearance due to solution, and its bluffs are marked by cavelike recesses which give it a rough, jagged appearance. (See Pl. XI, *B*, p. 78.) Bedding and joint planes are almost entirely absent. At a few localities the limestones are hard, white, and crystalline, and are sufficiently pure for use in the manufacture of lime. The softer rocks contain various percentages of silica and clay; the silica is generally not in the form of quartz grains but has been introduced in solution in circulating waters, replacing the limestone.

The limestones have been extensively silicified and the formation in many places consists of flint fragments and large siliceous bowlders in residual sands and clay; at no place, however, does the flint appear in continuous, solid, or undisturbed beds.

The flint is either porous and tripoli-like, or brittle, compact, and translucent, having been converted into jasper and chalcedony.

[1] Am. Jour. Sci., 3d ser., vol. 46, pp. 445–447, 1893.
[2] Science, new ser., vol. 12, pp. 873–875, 1900.

The white porous flint is prominent wherever the Vicksburg is the underlying formation. The white or cream color is due to the porous condition of the rock, the silica of which, when examined under the microscope, is seen to be in translucent grains, probably chalcedony. These flint rocks are in many places as fossiliferous as the limestones and are evidently replacements of the soft, porous limestones of the Vicksburg formation. The alteration in most places has been complete, the rock rarely showing effervescence with acids.

Some of the flint is dense, compact, vitreous or brittle, and either translucent or red, yellow, or brown. This variety shows fewer traces of fossils than the porous flint, but it is probably a replacement of the limestones, though jasper in the form of nodules in the limestones, apparently produced by the segregation of silica and not by replacement, has been observed at Albany.

Large bowlders of flint, picturesquely heaped, appear along Flint River from Albany to Bainbridge. The bowlders are characteristically vesicular and contain spherical cavities an inch or more in diameter, which appear to have been originally occupied by echinoids and which often contain a spongy, skeleton-like kernel of silica in place of the calcareous test.

The Vicksburg formation is deeply weathered, the weathered product appearing at the surface as deep-red argillaceous sands, containing scattered flint fragments and black and brown iron oxide accretions about the size of buckshot. In old railway and road cuts where the sands have been exposed for a long time they have become slightly cemented by iron oxide and crack into polygonal figures. At a number of places the residual clays and sands present a mottled appearance not unlike that of the late Oligocene beds. The freshly exposed residue of decomposition and solution is a highly siliceous bluish or gray tenacious clay.

Beds of sand which probably belong to the Vicksburg formation have been reported in a number of wells. In a cut on the Central of Georgia Railway half a mile east of Dawson two beds of varicolored sand, which do not appear to be residual, are associated with residual flint and clay.

Thickness.—The thickness of the formation can not be determined from natural exposures. A well boring at Lela, Decatur County (see log, p. 222), penetrated 400 feet of Vicksburg strata. Along the northern margin of the outcrop in Clay, Randolph, Webster, and Sumter counties the thickness is less than 100 feet. Spencer[1] estimated the thickness at Bainbridge to be 500 feet, but he probably included strata that should have been referred to older Eocene formations. The formation also appears in Burke and Screven counties,

[1] Georgia Geol. Survey First Rept. Progress, p. 55, 1890-91.

where the thickness probably does not exceed that in the western part of the State.

Paleontologic character.—The formation is highly fossiliferous, the most abundant forms being Foraminifera and Bryozoa. The flat, disklike foraminifer, Orbitoides, which varies from a quarter of an inch to 2 inches in diameter, is so common that the formation was formerly called the Orbitoidal limestone. The fauna of the Vicksburg formation possesses certain distinctive characteristics, although some of the common Vicksburg forms, such as Orbitoides and *Pecten perplanus* are also found in the underlying Jackson formation. *Amusium ocalanum* is a characteristic fossil. *Venericardia planicosta*, which ranges up into the underlying Jackson formation, has not been found in the Vicksburg formation. Common Vicksburg fossils are *Orbitoides mantelli, O. papyracea, Nummulites wilcoxi, Glycymeris arctatus, Pecten poulsoni, P. perplanus, Amusium ocalanum*, and *Cytherea sobrina*.

Physiographic expression.—The formation has exerted a notable effect on the topography. In general, surface areas underlain by it are more nearly level than those of the other older formations of the Coastal Plain. Underground solution has been extensive and the plains are dotted with lime sinks and with ponds which range from shallow circular depressions not more than 50 feet across to lakes occupying several hundred acres. The region is also characterized by a scarcity of small surface streams, much of the drainage being underground by way of the sinks.

Structure.—The beds are almost horizontal but dip slightly southeastward at probably not more than 8 feet to the mile—less than the dip of the underlying strata—as estimated from the supposed base of the formation at Americus and Cuthbert and the supposed base at Albany as determined from the record of an artesian well. No flexures or faulting have been observed, though some may be revealed by detailed geologic work, for it is certain that the Coastal Plain has undergone oscillations subsequent to the deposition of the Vicksburg formation.

APALACHICOLA GROUP.

The Apalachicola group in Georgia includes the Chattahoochee and Alum Bluff formations.

CHATTAHOOCHEE FORMATION.

Areal distribution.—The Chattahoochee formation appears at the surface in relatively small areas, being largely concealed by the overlying Alum Bluff and later formations. Good exposures occur along Flint River and in lime sinks near Recovery in Decatur County; and strata belonging to the formation were noted by Langdon[1] on

[1] Am. Jour. Sci., 3d ser., vol. 38, p. 324, 1889.

A. LIMESTONE OF THE CHATTAHOOCHEE FORMATION ON THE LEFT BANK OF WITHLACOOCHEE RIVER AT NEW BRIDGE (OR HORN BRIDGE) 3 MILES BELOW THE CROSSING OF THE VALDOSTA SOUTHERN RAILWAY, LOWNDES COUNTY.

B. ALUM BLUFF FORMATION ABOVE GRADYS (GRAYS?) LANDING, ALTAMAHA RIVER, TOOMBS COUNTY.

The materials are sands, clays, and sandy fuller's earth.

Chattahoochee River, 9 miles above River Junction, Fla. The formation appears at Forest Falls and other lime sinks in the northern part of Grady County, in the vicinity of Metcalf and Thomasville, Thomas County, and in the beds and bluffs of Withlacoochee and Alapaha rivers near the Georgia-Florida line. (See Pl. XII, *A*.) On Ocmulgee River near Abbeville and near Hawkinsville the formation is believed to be represented by fragmentary beds and by residual flint masses containing corals. Limestone, which outcrops near Jacksonboro on Briar Creek in Screven County, has been correlated by Vaughan with the Chattahoochee formation. Limestone, which outcrops in a small area northwest of Millen, Jenkins County, is provisionally considered as a part of the same formation; but the evidence for this classification is admittedly very meager. Limestone of the Chattahoochee formation has been discovered near Cordele, Crisp County, and limestone probably belonging to it outcrops 7 miles northwest of Sylvester. Strata of this formation are believed to outcrop in the escarpment east of Flint River from Crisp County to Decatur County but are largely obscured by weathering.

Buried representatives of the formation are believed to underlie nearly all the Coastal Plain of Georgia southeast and south of the areas of outcrop. The formation has been recognized on paleontologic evidence in a well boring at Tarboro, Camden County, between the depths 375 and 400 feet. (See p. 178.)

Stratigraphic position.—Pumpelly [1] and Vaughan [2] have recognized an erosion unconformity between the Chattahoochee and the underlying limestone of the Vicksburg formation in Decatur County. At Blue Springs, on Flint River 4 miles south of Bainbridge, both formations are present, but the contact between the two is much obscured by the weathering of both the Vicksburg and the Chattahoochee.

At Red Bluff, 7 miles north of Bainbridge, a contact similar to that at Blue Springs is exposed. The Chattahoochee formation appears as fragments of flint in residual sandy clay, and the weathered limestone of the Vicksburg formation appears at the base of the bluff. There is evidence of an erosion unconformity at this locality, and also at the bluff back of the old factory about 2 miles above Bainbridge. However, at Forest Falls, 8 miles northwest of Whigham, no unconformities were observed in a section the base of which, according to paleontologic evidence, is referable to the Vicksburg formation, and successively higher portions of which, on similar evidence, belong to the Chattahoochee and Alum Bluff formations.

Sedimentation was probably continuous from the beginning of Chattahoochee time to the end of Alum Bluff time, for no evidence of an erosion interval separating the two formations has been observed

[1] Am. Jour. Sci., 3d ser., vol. 46, pp. 445–447, 1893.
[2] Science, new ser., vol. 12, pp. 873–875, 1900.

in the field. McCallie,[1] however, has noted an unconformity at the old Toy phosphate pit, 3½ miles west of Boston; but whether this is due to erosion or to solution and irregular weathering of the limestone has not been determined. When this locality was visited by the authors the relations of the clay to the limestone had become obscured by the débris filling the pits.

Lithologic character.—The Chattahoochee formation is in general calcareous and varies from compact, pure, crystalline limestones to earthy argillaceous limestones and calcareous sands and sandstones. Compact, gray, drab, or white fossiliferous limestones make up the bulk of the formation. A brecciated or conglomeratic structure is characteristic of some of the beds, the phenomenon being observed at nearly all localities where there are good exposures. These conglomerate beds do not seem to be confined to a particular horizon, and their origin and significance are not well understood. Both the matrix and the angular or rounded fragments are limestone. Some beds appear to be pseudoconglomerates, and consist of a limestone matrix containing fossil echinoids whose structure has been partly obliterated, giving them the appearance of water-worn fragments. The rock is phosphatic at a number of places, containing brown or black rounded pebbles of phosphate or fragments of bones and teeth. The limestones at the base of the formation have been replaced by silica at several localities and at others are represented by fragmental beds of flint containing corals and other fossils in a matrix of residual clay. The flint closely resembles that of the underlying Vicksburg formation and can not everywhere be easily distinguished from it.

Thickness.—In the gorge northwest of Faceville, Decatur County, the Chattahoochee formation has a probable total thickness of 100 feet. At Forest Falls, or Limesink, in the northern part of Grady County, it has an exposed thickness of 60 or 65 feet. No very reliable data are at hand for estimating its total thickness to the east and northeast, under cover of later formations; but its maximum probably does not exceed 250 feet.

Paleontologic character.—Though no abrupt faunal break occurs between the Chattahoochee and Vicksburg formations and though some fossils are common to both, the two formations show marked differences. The base of the Chattahoochee contains a rich coral fauna which, in the vicinity of Bainbridge, has been studied by T. W. Vaughan.[2] He estimated that in a coral reef 4 miles south of Bainbridge there were between 25 and 30 species of corals, and he correlated the beds with the Oligocene of Antigua. The characteristic Vicksburg species *Amusium ocalanum* does not appear, and,

[1] Georgia Geol. Survey Bull. 5-A, p. 62, 1896.
[2] Science, new ser., vol. 12, pp. 873-875, 1900.

though the genus Orbitoides is common to both the Vicksburg and Chattahoochee formations, most of the Chattahoochee species are different from those of the Vicksburg. *Orbitolites complanata* occurs in the Chattahoochee formation, but has not been found in the Vicksburg. *Orthaulax pugnax*, a gastropod common in the Tampa formation of Florida, has been found at two localities.

Physiographic expression.—In portions of Decatur, Grady, Thomas, Brooks, and Lowndes counties, where the Chattahoochee formation lies near the surface, the topography is a little more hilly and rugged than in other parts of southern Georgia. Lime sinks, lakes, and ponds due to the underground solution and consequent caving in of the limestones of the formation are notable features of the topography.

Structure.—The formation is tilted slightly southward and southeastward. The dip is low, probably not over 8 feet to the mile. The top of the formation is estimated to be about 225 feet above sea level at Forest Falls or Limesink, and about 200 feet above sea level near Faceville, approximately 24 miles to the southwest. At Red Bluff, 7 miles north of Bainbridge on Flint River, where Vaughan has determined paleontologically the presence of the Chattahoochee, its base can hardly be more than 20 feet above the river, and at Blue Spring, 4 miles below Bainbridge, is about 10 feet above the river. This indicates a very low dip.

Local dislocations of beds, due to underground solution and consequent sinking, have been observed in Thomas and Decatur counties.

ALUM BLUFF FORMATION.

Areal distribution.—The Alum Bluff formation outcrops in southern and south-central Georgia throughout a large area extending from Decatur County northeastward to Savannah River. The limit of the deposits of the Alum Bluff as they exist to-day is approximately marked on the north by Waynesboro, Tennille, and Vienna; on the west by the west-facing escarpment which separates the Altamaha upland from the Flint River valley; and on the east by a line extending from Savannah River near the mouth of Buck Creek through Sylvania, Reidsville, and Blackshear to the western edge of Okefenokee Swamp.

The formation includes typical marine invertebrate-bearing gravels, sands, clays, and marls and irregularly bedded nonfossiliferous sands, gravels, and clays. All the deposits are of shallow-water origin. The upper part of the formation is usually coarser grained than the lower. Pebbles occur in its upper part just below the Miocene contact at Porters Landing on Savannah River, where it contains abundant marine fossils.

ALUM BLUFF FORMATION, MARKS HEAD MARL, AND DUPLIN MARL, PORTERS LANDING, SAVANNAH RIVER, EFFINGHAM COUNTY.

Photograph by S. W. McCallie.

The first comprehensive description of the physiographic aspect and lithologic character of the formation as exposed in Georgia was published by R. H. Loughridge,[1] who correlated it with the "Grand Gulf sandstones" of the Gulf States. His description is as follows:

> Included between the Savannah River and the Atlantic and Gulf water divide there seems to have been once formed a large shallow basin, which is now filled with a sandstone composed for the most part of coarse angular grit and clay, partly cemented with silica and resembling in character the Grand Gulf sandstone of the Gulf States. The area is marked on the map by the deep-green color of the pine barrens region, whose soils overlie the formation. The rocks have a slight dip to the southeast and have been traced by Capt. M. T. Singleton (now of the United States Engineer Corps, engaged in river improvement) for 60 miles along Oconee River, and he estimates the thickness to be 200 feet. Outcrops have been observed in Irwin, Dodge, Ware, and other counties. Paramore's hill, in the western part of Screven County, is of this sandstone, which here has a thickness of 50 feet or more. Its grains of quartz are partly clear and translucent and partly white and opaque and the rock is highly aluminous.
>
> The southern limit of the sandstone is apparently at the edge of the second terrace, near the coast and along Satilla River north of Okefenokee Swamp, but the formation (represented by blue clays underlying the sandy lands) extends probably still southward, including in its area the country near the Florida line between Alapaha River east to the ridge on the eastern side of the swamp—a part of the main Atlantic and Gulf water divide of the State.

The name "Altamaha grit" was proposed for the same deposits in 1892 by Dall,[2] who regarded the typical beds along the Altamaha River as contemporaneous in a general way with the older Miocene, which was later classified by the same author and others as upper Oligocene. He says, regarding the deposits:

> Though the contact with the oyster-bearing Hawthorne beds of House Creek was not observed by Mr. Burns, there can be little doubt that the latter are overlain by the grit where they join, and that the grits which contain no fossils except a little silicified wood are consequently of Miocene age. Seaward from them marine Miocene beds of the Chesapeake series were doubtless laid down, since Conrad records the washing up on St. Simons Island of a specimen of Ecphora.

He also states:

> * * * The last bluff of the grit is only a few rods above the bridge across the Altamaha River at Doctortown, the piers of the bridge resting upon a newer formation. [This bed is Chesapeake Miocene.]

"The oyster-bearing Hawthorne beds of House Creek" also belong to the Alum Bluff formation and are not stratigraphically separable from the Altamaha grit of Dall.

Harper[3] in 1906 and Veatch[4] in 1908 correlated the same deposits with the Pliocene. Harper reiterated the correlation of the Altamaha with the "Grand Gulf" of the Gulf States. Veatch and

[1] Loughridge, R. H., Cotton production of the State of Georgia: Tenth Census, vol. 6, Georgia, pp. 15, 16 (281, 282 at bottom of page), 1884.

[2] Dall, W. H., U. S. Geol. Survey Bull. 84, p. 82, 1892.

[3] Harper, R. M., New York Acad. Sci. Annals, vol. 17, pt. 1, p. 18, 1906.

[4] Veatch, Otto, Science, new ser., vol. 27, pp. 71-74, 1908.

ALUM BLUFF FORMATION, MARKS HEAD MARL, AND DUPLIN MARL, PORTERS LANDING, SAVANNAH RIVER, EFFINGHAM COUNTY.

Photograph by S. W. McCallie.

A. QUARTZITE OF THE ALUM BLUFF FORMATION IN THE FIRST CUT OF THE SOUTHERN RAILWAY SOUTHEAST OF THE BRIDGE OVER OCMULGEE RIVER IN JEFF DAVIS COUNTY.

B. LOWER SISTERS BLUFF, ALTAMAHA RIVER, APPLING COUNTY, SHOWING SANDS AND CI OF THE ALUM BLUFF FORMATION.

Stephenson[1] in 1911 questionably referred the formation to the Pliocene, although they recognized that the term Altamaha formation, as used by them, and also as previously used by Harper and by Veatch, included strata ranging in age from Oligocene to Pleistocene.

The investigations of recent years have led to the conclusion that the bulk of the deposits included by Harper, Veatch, and Stephenson in the Altamaha formation are of Oligocene age and are probably contemporaneous with a part of the Alum Bluff formation.

Marine fossils are rare in most of the exposures of the Alum Bluff formation, but they have been found in Decatur, Grady, Thomas, Lowndes, Echols, Wilcox, and Effingham counties. Excellent exposures appear in the bluffs of Ocmulgee and Altamaha rivers from near Abbeville to Doctortown. (See Pl. XII, *B*, p. 86; Pl. XIII, and Pl. XIV, *A* and *B*.)

Except along streams, along escarpments near streams, and near the Florida line, the entire area underlain by the Alum Bluff formation is mapped as "Undifferentiated Oligocene to Pleistocene, inclusive." The inland boundary of the formation has not been accurately ascertained, nor has the boundary between it and the Miocene been definitely traced; however, it is probable that the Alum Bluff is the immediately subsurficial or the surficial formation westward from a line passing through Rocky Ford and Waycross to somewhat beyond the inland margin of the Chattahoochee formation, as there is considerable evidence in favor of the latter formation being overlapped by the former. There is discrepancy in the treatment of the area underlain by the Alum Bluff as compared with that of the areas underlain in the Coastal Plain by older Tertiary formations, for that underlain by it is represented as covered by undifferentiated deposits ranging in age from Oligocene to Pleistocene, whereas in the areas of the other formations account is not taken of Pleistocene deposits along stream valleys and of what are perhaps overwash deposits associated with stages in drainage development. Consistent treatment of the Alum Bluff formation would have led to omitting the color representing "undifferentiated Oligocene to Pleistocene" over the area the surface of which it is indicated as underlying. This inconsistency is mostly to be attributed to the present incomplete knowledge of its inland and seaward boundaries.

Stratigraphic position.—The Alum Bluff formation conformably overlies the Chattahoochee formation, and the exact boundary between the two is in places drawn arbitrarily, for there is neither abrupt lithologic nor faunal change from the one to the other. There are in places apparent unconformities due to solution and weathering of the limestone of the Chattahoochee near the contact. On Savannah and Altamaha rivers the Alum Bluff formation is separated from

[1] Georgia Geol. Survey Bull. 26, pp. 400–423, 1911.

the overlying Miocene by an erosion unconformity, probably of minor importance. Throughout the greater part of the area underlain by the Alum Bluff formation its weathered products, in places perhaps overlain by more recent deposits, are believed to form the surface material; but in southeastern Georgia it is overlain by lithologically similar undifferentiated deposits, ranging in age from Miocene to Pleistocene. Owing to the lithologic similarity of the materials forming or overlying the surface of the Alum Bluff no attempt has been made to differentiate them on the map, their discrimination being left for future work.

In narrow areas along all the larger streams the Alum Bluff formation is overlain by thin terrace deposits of Pleistocene age.

Lithologic character.—The Alum Bluff formation appears in a number of different lithologic phases, including subordinate beds of pebbles, coarse angular sands, coarse-grained aluminous sandstones or grits, sandy clays, fuller's earths, phosphatic sands, quartzites, sandstones, silicified clays, and limestones or calcareous layers and nodules of local extent. Greenish or gray argillaceous sands and sandy laminated clays form the greater part of the formation.

Beds of fuller's earth occur in the formation both in Georgia and in Florida. The fuller's earth is generally a gray or drab, faintly laminated, claylike earth of low specific gravity. The earth is generally rather hard and brittle and in many places has been so silicified that it is very hard and rocklike and has lost its characteristic properties. Segregations of silica in the form of small, round, or flattened nodules are characteristic. The fuller's earth beds do not attain great thickness and are not persistent over large areas, but appear to be local phases in sands and sandy clays. Greenish and drab sticky plastic clays and argillaceous sands are associated with the fuller's earth.

Phosphatic sands on Alapaha and Suwannee rivers are believed to lie directly above the Chattahoochee formation. Sands of the Alum Bluff formation on Savannah River are also slightly phosphatic. These sands are generally unconsolidated or only slightly indurated. In places they are coarse grained and even contain small pebbles, and in many places they are cross-bedded. They consist largely of quartz, the phosphate content being in the form of small brown or black slick nodules or water-worn pieces of bones and teeth, varying in size from a pinhead to three-fourths of an inch in diameter. A little clay is generally present. The sands, in a number of places, are calcareous and contain calcareous phosphatic nodules. A chemical analysis by Edgar Everhart, former chemist of the Geological Survey of Georgia, of a sample of sand from Suwannee River 9 miles below Fargo showed 16.8 per cent of phosphoric acid (P_2O_5).

The clay and fuller's earth phases of the formation have in places been silicified to such an extent that they have been converted into very hard clay stones, and the argillaceous sands have become dense, vitreous, and brittle quartzites. The clay breccias and conglomerates have likewise been silicified. In fact, alteration of the rocks by silica carried in solution by circulating waters has taken place in some degree throughout the greater part of the formation. Opal and agate occur in places as a result of this silicification.

Samples of the silicified clays from Withlacoochee River, 7 miles east of Quitman, were examined in the laboratory. They vary from bluish to light-greenish and dove color, are hard, brittle, and break with a conchoidal fracture, and are dense and compact, with cracks filled with opaline silica. Some of these rocks are slightly phosphatic. Some phases, which might be termed "opalized clay conglomerates" or "breccias," originally consisted of pebbles or angular fragments of clay in a matrix of very sandy lighter-colored clay or argillaceous sand that in places contains oyster shells. By the infiltration of opaline silica, the rock has become dense, compact, and in many places vitreous or glassy to such an extent that the sand grains are no longer recognizable. The clay is about 3 in the scale of hardness and it requires a strong blow with the hammer to break it. The oyster shells have become opalized and agatized, the lime having been replaced by silica.

In Grady, Brooks, and Thomas counties thin beds of white sandstone, usually soft, are associated with sandy clays and are often phosphatic, the phosphate being in part the cementing agent.

Thickness.—The maximum thickness of the Alum Bluff formation in Georgia is estimated to be 150 to 200 feet. At no known locality can the full thickness of the formation be seen in natural exposure, and the estimate is based chiefly on well records. Records at Lumber City, in Telfair County, indicate a thickness of over 200 feet. Some of the natural exposures on Savannah River reveal a thickness of 70 or 80 feet.

Paleontologic character.—A few fossils have been found in the marine beds of the formation in Georgia, most of them being in the form of casts and impressions. T. W. Vaughan obtained a number of species in the vicinity of Bainbridge, and a well-preserved oyster, *Ostrea mauricensis,* is found at several localities. The formation seems to mark the disappearance of the species of Orbitoides which are so common in the Vicksburg and Chattahoochee formations Among the characteristic fossils are *Turritella alcida* Dall, Carolia, and *Pecten madisonius* var. *sayanus* Dall.

Physiographic expression.—The area over which the Alum Bluff formation is represented on the map as being at the immediate surface is relatively small, although in the southeastern part of Decatur

and in the southern parts of Grady, Thomas, Brooks, and Lowndes counties a relatively broken and hilly topography has been produced by its erosion and weathering. This erosion is due chiefly to the character of the drainage and the structural features.

The higher divides and uplands underlain by the formation and mapped as "undifferentiated Oligocene to Pleistocene, inclusive," present a peculiar topography. Part of this area constitutes the Altamaha upland, one of the major topographic divisions of the Coastal Plain of Georgia (pp. 32–34), an area of low hills with gentle slopes and softened outlines, of shallow saucer-shaped valleys, many of which are not more than 40 or 50 feet deep, of sluggish clear-water streams bordered by swamps and sand hammocks, and of "bays" and cypress ponds.

Altamaha and Oconee rivers have cut deep valleys, and the precipitous bluffs along their courses form an exception to the general type of topography of the area. The low hills and gentle slopes of the main area present a notable contrast to the broken hilly areas of the Cretaceous and Eocene near the fall line, with the lime-sink topography to the west and southwest, and with the flat sand-coated plains to the southeast.

Structure.—The Alum Bluff formation has a very low southward and southeastward dip, certainly much less than that of the older Eocene and Vicksburg formations. On Savannah River the dip does not exceed 4 or 5 feet to the mile, and near the Florida line the beds must be almost horizontal, for the streams have cut through them, exposing the underlying formations. No evidence of broad flexures nor even minor folding and faulting was observed in the natural exposures of the strata. However, the probability that a broad arch exists in the southern part of the State has been mentioned. (See p. 59.)

UNDIFFERENTIATED OLIGOCENE TO PLEISTOCENE, INCLUSIVE.

The materials designated "Undifferentiated Oligocene to Pleistocene, inclusive," on the geologic map have been partly discussed under Alum Bluff formation (p. 91), and under Miocene series (pp. 97–98).

The bulk of the deposits previously included by the writers and by others in the Altamaha formation and referred questionably to the Pliocene are now regarded by them as Oligocene and as probably contemporaneous with part of the Alum Bluff formation. (See p. 91.) This material consists of irregularly bedded, locally indurated sands, clays, and gravels. On the whole the individual beds are homogeneous, but locally they are a heterogeneous mixture. The indurated sands and the conglomerates contain a peculiar greenish or greenish-gray disseminated clay and are described as "gray or greenish aluminous grits." The pebbles are predominantly subangular, many of

A. GREENISH-GRAY ARGILLACEOUS FELDSPATHIC SANDSTONE OF THE ALUM BLUFF FORMATION, KNOWN AS "THE ROCKS," NEAR THE HEAD OF A SMALL BRANCH 8 OR 9 MILES EAST OF NORTH OF BROXTON, COFFEE COUNTY.

B. WEATHERED PHASE OF LATE OLIGOCENE BEDS IN A CUT OF THE ATLANTIC COAST LINE RAILROAD WEST OF CAIRO, GRADY COUNTY, SHOWING CHARACTERISTIC MOTTLING.

them lath shaped, and the sands are universally harsh or in sharp angular grains. Feldspar is present in great abundance, both as pebbles and as semidecomposed disseminated grains, and phases of the deposits may be appropriately described as "feldspathic grit." Calcareous phases are totally absent. The weathered surface materials are mottled and splotched in red, yellow, purple, and gray, the surface aspects differing in this respect from those of any other formation of the Coastal Plain. (See Pl. XV, *B*.) These striking effects are probably due to unequal weathering, oxidation, and unequal distribution of iron materials. This peculiar surface phase is not a later deposition but results from weathering, although in many places it appears to overlie unaltered beds unconformably. The materials are very coarse grained, even at points 100 miles from their northern margin. The beds that have been locally indurated to sandstones, conglomerates, and claystones, do not differ essentially in composition from the nonindurated materials.

The grit and sandstone phases, the peculiar nature of which attracted the special attention of those who first studied the terrane, are typically exposed along Altamaha River (Pl. XIV, *B*, p. 91), where they appear as gray or greenish, aluminous sandstones, more or less mottled and stained by iron oxide. At some localities pebbles are embedded in the sand and clay matrix and the whole cemented into a conglomerate; but except for the pebbles these beds do not appear different from the usual sandstones of the Alum Bluff formation. The percentage of clay in the indurated rock varies from 5 per cent to a percentage sufficiently high to render the rock an indurated clay rather than a sandstone. The sandstones are generally soft and friable, the cementing material being an opaline silica, but locally the rock is extremely hard. In places the sandstones are arkosic; that is, they are composed of quartz, feldspar, mica, and other minerals originally derived from igneous rocks and have their interstices filled with clay, the whole being cemented with silica, producing rocks not unlike some of the indurated phases of the Lower Cretaceous strata near the fall line. These lithologic peculiarities have been observed at widely separated localities and are everywhere easily identified, although entirely devoid of fossils. Except along Altamaha River, surface outcrops are not abundant. In the interstream areas there are some small tracts a few acres in extent, in which jutting beds of sandstone 15 or 20 feet thick form barren rocky flats. Exposures of grit or hard rock are most common in the northern part of the Altamaha upland (see Pl. XV, *A*) but are not observed near the coast or near the Florida boundary line. It is believed that these isolated exposures are local indurations only and do not form continuous sandstone beds.

The clays, which are similar to those of the Alum Bluff formation, are fairly uniform in texture and composition throughout the area of their occurrence. They are greenish or drab, very fine grained and plastic, and are everywhere more or less sandy. They have a low specific gravity, absorb a high percentage of water, and occur in thick irregular pockets or thin lenticular layers, nowhere persisting as individual beds over any large area. In places they grade into or are abruptly replaced by sands and sandstones. Greenish clay, full of coarse angular quartz particles and subangular decomposed feldspar pebbles is common. The clays are locally indurated, the cementing material being opaline silica.

The sands consist chiefly of coarse quartz grains and are red and yellow, or orange, or less commonly brownish in color. They are more or less argillaceous and locally contain layers or lenses, rarely more than 8 or 10 feet thick, of quartz and feldspar pebbles. The feldspar pebbles constitute a large percentage of the gravel layers. A characteristic of the pebbles is their angularity, some being lath shaped and showing scarcely any rounding of the angles. At a few localities the pebbles are rather large, attaining a diameter of 4 to 5 inches. The pebbly feature is nowhere very prominent and is exceptional rather than general. Where the pebble beds are indurated, the cementing material is clay, opaline silica, and iron oxide. In the southwestern part of the State, near Whigham, in Grady County, the sands are, in places, fine grained, cross-bedded, and rarely micaceous, and are interstratified with thin layers and leaves of plastic clay which do not exceed an inch in thickness.

In the northern part of the region the sands are everywhere coarse. It is only near the Florida State line that they are fine grained and even here they contain some coarse-grained materials. They are nowhere pure, and they contain large amounts of disseminated clay.

The sands, clays, and sandstones, although described separately in the foregoing paragraphs, do not form beds of more than local extent. Irregularity of bedding is characteristic and in many of the exposed sections the sands, clays, and sandstones are present in interlocking small lenses or merge abruptly into each other horizontally. In places the sands and gritty clays may be seen to grade horizontally from nonindurated to indurated rocks, or from soft sands and clays into grits.

Brown iron-oxide "pebbles" or nodules are so abundant at many places as to warrant special mention. They occur throughout the wire-grass region in such quantity as to cause the lands to be termed "pebble" or "pimple" land in contrast to the lands covered by the residual gray sand alone. Pebble land is generally recognized as being superior in productiveness. These nodules are a surface phenomenon produced by weathering, which causes the iron oxide

of the argillaceous sands to segregate into irregular small bodies which are subsequently worn smooth. The pebbles vary in size from buckshot to 10 inches in diameter, but the buckshot size is most common. They are composed of limonite or some closely allied iron mineral with clay and sand impurities. They are round, tubercular, or irregular in shape, and have a slick or water-worn appearance, but as there is not much evidence of their having been transported by water their smoothness may be due to attrition by raindrops. These pebbles were noted as being especially abundant at Stillmore, Fitzgerald, Douglas, Pelham, and Doerun.

The age of most of this material west of a line from Rocky Ford to Waycross is believed to be upper Oligocene. East of that line it probably ranges in age from Miocene to Pleistocene.

MIOCENE SERIES.

GENERAL FEATURES.

In earlier geologic literature the Chattahoochee and Alum Bluff formations were referred to the Miocene. In fact all the beds between the Vicksburg and the Pliocene or Pleistocene in the south Atlantic and eastern Gulf regions were regarded as belonging to this series. However, W. H. Dall recognized an "old or subtropical Miocene" and a "new or Chesapeake Miocene." Later[1] he referred the so-called "old Miocene" to the Oligocene. The Miocene as treated in this report includes only the deposits formerly designated "new or Chesapeake Miocene," which lie between the Alum Bluff formation and the Pliocene on Pleistocene deposits.

T. W. Vaughan[2] has recently made a paleontologic study of the section at Porters Landing, Savannah River, Effingham County, and has correlated the upper part of the Miocene there exposed (=Edisto phase of Sloan[3]) with the Duplin marl of North Carolina, and the lower part (Marks Head of Sloan) approximately with the Calvert formation of Maryland.

Except in the exposures in the vicinity of Porters Landing, at Mount Pleasant Landing, and at Sisters Ferry, it has not been possible with the available data to differentiate the Marks Head and Duplin marls in the Savannah River sections, though doubtless both formations are represented, at least from Hudsons Ferry in Screven County to Sisters Ferry in Effingham County.

Fossils of Miocene age have been recognized in dredgings from Brunswick River at Brunswick, Glynn County, but they had been

[1] U. S. Geol. Survey Eighteenth Ann. Rept., pt. 2, pp. 329-332, 1898. U. S. Nat. Mus. Proc., vol. 19, No. 1110, pp. 303, 304, 1896.

[2] Science, new ser., vol. 31, No. 804, pp. 833-834, 1910.

[3] According to Vaughan the Edisto of Sloan in the Porters Landing section is much younger than the Edisto of Sloan in the vicinity of Charleston.

mixed by the dredging processes with large numbers of shells younger than Miocene. Limestone, tentatively referred to the Miocene, occurs on the Livingston plantation, 18 miles west of Brunswick, in Glynn County, and a calcareous sand of Miocene age occurs at Owens Ferry, Satilla River, 8 miles west of Woodbine, Camden County.

It is believed that strata of Miocene age underlie much of the region adjacent to the Atlantic coast beneath beds of younger age, and it is considered not improbable that such strata may reach a thickness of 200 or 300 feet. However, confirmatory evidence is lacking.

The marine invertebrate-bearing beds of the Miocene which outcrop on Savannah and Altamaha rivers and which lie buried beneath younger deposits in a zone adjacent to the coast are believed to have coarser shoreward phases represented in the undifferentiated Oligocene to Pleistocene deposits indicated on the map as a belt between the Alum Bluff formation and the known Pleistocene formations.

MARKS HEAD MARL.

Areal distribution and structure.—The Marks Head marl has been differentiated at and in the vicinity of Porters Landing, Savannah River, Effingham County (Pl. XIII, p. 90), and is doubtless represented in the undifferentiated Miocene in the sections above Porters Landing, at least as far as Hudsons Ferry, and in the sections between Porters Landing and Sisters Ferry.

The formation is almost entirely concealed by younger sediments and outcrops only in the bluffs of streams. For this reason it has had little or no influence on either the topography or the soil of the region. So far as can be determined from natural exposures, it lies almost horizontal, having only a very slight dip southward, probably not more than 4 feet to the mile.

Stratigraphic position.—The Marks Head marl rests upon the Alum Bluff formation of the Oligocene, from which, according to exposures on Savannah River, it is separated by an erosion unconformity. However, both the physical and faunal evidence seems to show that the time interval represented by this unconformity was relatively short. The formation is overlain unconformably by the Duplin marl, and as the Marks Head marl is early Miocene and the Duplin marl late Miocene the unconformity separating them is important.

Lithologic character and thickness.—The beds of the formation consist of gray or brownish compact argillaceous sands containing large calcareous nodules and, in places, of friable phosphatic sands containing shells. The phosphatic sands consist mainly of quartz grains with subordinate percentages of phosphate in the form of small, brown and black, smooth or water-worn particles of bones and teeth, disseminated clay, and calcium carbonate in the form of shells and

calcareous nodules. A maximum observed thickness of 45 feet occurs in some of the sections in the vicinity of Porters Landing on Savannah River.

Paleontologic character.—The formation has yielded a relatively small fauna, the collections coming chiefly from localities in the vicinity of Porters Landing, Savannah River. The fossils have been studied by T. W. Vaughan, who says:

> The presence of Carolia in this bed suggests Oligocene, but every other identifiable species may be Miocene, and only three others range downward into the Oligocene; nine species are not known below the Miocene; of these nine, six are confined to the Miocene. The horizon is, therefore, in the Miocene, while the presence of *Turritella æquistriata* Conrad, *Calliostoma aphelium* Dall, *Ostrea mauricensis* Gabb, and *Pecten marylandicus* Wagner, definitely points to a horizon low in the series.

DUPLIN MARL.

Areal distribution and structure.—The Duplin marl has been differentiated in the sections at Porters Landing and at Mount Pleasant Landing, 1½ miles below Porters Landing. The formation is doubtless represented in undifferentiated Miocene beds recognized in bluffs above Porters Landing as far as Hudsons Ferry, and below Porters Landing perhaps as far as Purisburg, S. C., 23 miles above Savannah. The formation has also been differentiated at Doctortown, at Buzzards Roost Bluff, and at Bugs Bluff on Altamaha River. The terrane probably underlies surficial formations throughout much of the region intervening between its exposures on Altamaha and Savannah rivers.

The Duplin strata dip southeastward at a low angle, probably not greater than 3 or 4 feet to the mile. Except in a few stream bluffs the formation is probably concealed over the entire area of its occurrence by surficial deposits, and for this reason has had little or no part in determining the topographic features or the character of the soils.

Stratigraphic position.—The Duplin marl rests unconformably upon the Marks Head marl, or, where the latter is absent, upon the Alum Bluff formation of the Oligocene. The former relations were observed in sections examined at and in the vicinity of Porters Landing, Savannah River, and the latter relations are believed to obtain in sections on Altamaha River, at the bluff at Doctortown, at Buzzards Roost Bluff, and at Bugs Bluff.

In the vicinity of Porters Landing the formation is overlain by terrace deposits of Pleistocene age.

Lithologic character.—The formation as exposed on Savannah River is mainly a shell marl, consisting of shells in a matrix of coarse phosphatic sand, but in places is a fine gray or brown quartz sand containing scarcely any fossils or calcareous matter. On Savannah River it probably does not reach a thickness of more than 10 to 12 feet.

On Altamaha River the Duplin marl consists of 12 or 15 feet of friable, sandy, and pebbly shell marls, and bluish, compact, fine-grained, argillaceous, fossiliferous sands. It overlies, unconformably, strata of probable Alum Bluff age and is in turn overlain by undifferentiated, varicolored sands and clays which probably belong in part to the Pliocene and in part to the Pleistocene.

Paleontologic character.—The Duplin marl has yielded a fairly large number of species in Georgia, although much fewer than in the type region in North Carolina. The collections were made chiefly at Porters Landing, on Savannah River, but a few species have been identified from Doctortown and from Buzzards Roost Bluff, on Altamaha River. T. W. Vaughan furnishes the following statement in regard to these:

Total number of identified species, 34 (not counting varieties), 30 of which are also at Duplin. The 4 species which have not been found there are as follows:

Pteria colymbus Bolten, the previously known range of which was from the Caloosahatchee Pliocene to Recent, or younger than the Duplin.

Astarte distans var. *floridana* Dall. Miocene of Jackson Bluff, Fla., approximately the Duplin horizon.

Phacoides multilineatus (T. & H.) Known range from the Miocene of Maysville, S. C., to Recent; from the Duplin to Recent.

Transennella caloosana Dall. Known range from Miocene of Jackson Bluff, Fla., to Pleistocene; from approximately the Duplin to Pleistocene.

The bed whence the fossils came is evidently the stratigraphic equivalent of the Duplin marl of North Carolina.

PLIOCENE (?) SERIES.

DISTRIBUTION.

Although the existence of strata of Pliocene age in Georgia has not been definitely proved, certain deposits have been referred with greater or lesser degrees of confidence to this epoch. The deposits of the Atlantic and Gulf Coastal Plain to which the name Lafayette formation has been applied have for many years been regarded as of probable Pliocene age.

The Lafayette formation is represented by McGee as covering the entire Coastal Plain of Georgia, and has been described by different investigators from numerous localities in Georgia. Recent investigations have shown, however, that many and perhaps all of these correlations were erroneous. Several of the beds so referred have been found to belong to Cretaceous, Eocene, or Oligocene formations or to be the weathered residual products of these formations. Terrace deposits which are clearly of Pleistocene age have also been referred to this formation.

The authors have examined certain remnantal deposits of gravel on the divides near the fall line, chiefly in the vicinity of Augusta, Macon, and Columbus, which previous workers had regarded as

A. CHARLTON FORMATION, ST. MARYS RIVER (FLORIDA SIDE), 1 MILE ABOVE TRADERS HILL, CHARLTON COUNTY.

B. BEARDS BLUFF, ALTAMAHA RIVER, TATTNALL COUNTY, SHOWING PROMINENT CLAY LAYER IN THE SATILLA FORMATION, OVERLAIN BY LOOSE SAND.

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belonging to the Lafayette formation. The authors believe that the Lafayette in Georgia is represented, if at all, by these deposits, but even as to these they have strong doubts, considering it more probable that some of them are remnants of the basal conglomerates of Cretaceous or Eocene formations that formerly overlapped the area, and that others are lenses of gravel in these older formations, the relations of which have become more or less obscured by weathering. These deposits are all north of the area in which the Alum Bluff formation is represented as outcropping.

Certain fossiliferous strata exposed on Satilla and St. Marys rivers have, on paleontologic evidence, been considered as probably of Pliocene age and are described under the name Charlton formation. These marine strata probably have littoral shallow-water representatives in the undifferentiated Oligocene to Pleistocene deposits to the north in Ware, Pierce, Appling, and Wayne counties. (See geologic map, Pl. III, p. 52.)

CHARLTON FORMATION.

The name Charlton is derived from Charlton County, Ga., and is applied to an argillaceous limestone and clay formation exposed in the banks and bluffs of St. Marys River from Stokes Ferry, 11 miles south of St. George, Charlton County, to Orange Bluff, near Kings Ferry, Fla. (See Pl. XVI, *A*.) From a study of the fossil collections from the St. Marys localities T. W. Vaughan has classified the formation as probably Pliocene.

Fossiliferous marls probably referable to the formation have been observed on Satilla River at Burnt Fort, 12 miles northeast of Folkston, Charlton County; on land of W. M. Thrift, 6 miles east of Winokur, Charlton County; and at the King plantation, 6 miles south of Atkinson, Wayne County. Fossils from the last-named locality have been referred by Aldrich [1] and Dall [2] to the Pliocene. General considerations based on structure and on the lithologic character of the materials seem to justify the reference of this marl bed to the Charlton formation.

The relations of the Charlton formation to the Miocene are not definitely known. From Stokes Ferry, where the top of the formation is perhaps 30 or 35 feet above sea level, the upper nonconformable surface descends gradually downstream and finally reaches tide level. According to the geologic map of Florida, by Matson and Clapp,[3] the Jacksonville formation (Miocene) outcrops at elevations of 50 to 100 feet above sea level a short distance south and east of St. Marys River. Beds from which T. W. Vaughan has identified Miocene fossils are exposed at low tide at Owens Ferry, Satilla River, Camden

[1] Nautilus, vol. 24, No. 11, p. 131, 1911.
[2] U. S. Nat. Mus. Proc., vol. 46, pp. 226, 227, 1913.
[3] Florida Geol. Survey Second Ann. Rept., 1909.

County. In view of these occurrences of Miocene the Pliocene beds on St. Marys River, if correctly correlated, may occupy an erosion basin in Miocene strata, or, if the latter are absent beneath them, they may rest in a similar basin in pre-Miocene strata probably referable to the Alum Bluff formation (Oligocene). The great thickness attributed to the Miocene at Jacksonville, 460 feet, and the fact that the Miocene there is supposed to lie unconformably upon the Vicksburg makes the former alternative seem the more probable. There are no data for estimating the thickness of the formation, for only 12 or 15 feet of strata have been observed in natural exposures.

The strata are poorly fossiliferous, and it is difficult to correlate them by means of their fossils. The formation is characterized at two or three localities by an abundance of ostracodes.

With regard to the age of the formation, T. W. Vaughan says:

> None of the material [fossils] between Hicks Bluff and Orange Bluff [St. Marys River] can be older than Pliocene, and although not a single extinct species was collected, it may be Pliocene. The two species of ostracodes listed by Dr. Bassler from Rand Landing and Clay Landing appear to be Recent. As the material from Stokes Ferry seems to be the same as that from Rand and Clay landings it is probably the same age [Pliocene].

QUATERNARY SYSTEM.

PLEISTOCENE SERIES.

SUBDIVISIONS.

The Pleistocene deposits consist of thin accumulations of sand, clay, and gravel on terraces of fluviatile and marine origin. The only systematic description of the Pleistocene of the Coastal Plain of Georgia previously given is that of McGee.[1] McGee first studied the Pleistocene in the District of Columbia, gave it the name Columbia formation, and differentiated it into three phases, the fluvial, interfluvial, and low-level phases. He traced the formation southward to the Mississippi and to Mexico, recognizing the three phases in Georgia, and giving brief general descriptions of them. Previous to McGee's studies Lyell and other observers had already noticed successive terraces on the coast of Georgia, but had apparently failed to recognize their geologic significance.

The classification given in the present report is based largely on topography, and the formations are described in greater detail than in McGee's report. The name Columbia as a group term is retained. The divisions are as follows:

Satilla formation:	Okefenokee formation:
Marine terrace deposits.	Coastal terrace sand.
Fluviatile deposits.	Fluviatile deposits.

[1] McGee, W J, The Lafayette formation: U. S. Geol. Survey Twelfth Ann. Rept., pt. 1, pp. 384–407, 1891.

The solution of the Pleistocene problems of Georgia, and in fact those of the Atlantic coast region in general, is conditioned largely on a knowledge of topographic details, which can not be acquired until detailed topographic maps have been made.

In Georgia the Pleistocene formations are not superimposed one upon the other but occupy terraces at different topographic levels.

During the Okefenokee epoch gray sands and other sediments were laid down on a terrace plain of probable marine origin, now 60 to 125 feet above sea level, and contemporaneous fluviatile deposits of gravel, sand, and loam were laid down on the "second" terrace skirting the larger rivers.

During the Satilla epoch gray sands and muds were laid down on a marine terrace, a flat plain 20 to 40 miles broad, bordering the coast at elevations of 15 to 40 feet above sea level, and corresponding terrace alluvium was deposited along the rivers.

Although the available data are too incomplete to permit positive statements, it is not improbable that an older Pleistocene terrace plain exists west of and at a higher elevation than the Okefenokee terrace. Evidence of such a plain is to be seen in the topographic aspect of the country along the Atlantic Coast Line Railroad between Valdosta, Lowndes County, and Waycross, Ware County; along the Atlantic Coast Line Railroad between Pearson, Coffee County, and Waycross; and along the Southern Railway between Baxley, in Appling County, to near Jesup, Wayne County. The general surface of the belt of country crossed by these railroads is a nearly level plain which gradually descends toward the coast. Along the first-mentioned railroad there is a descent from an elevation of 215 feet at Valdosta to 140 feet at Waycross; along the second there is a descent from 205 feet at Pearson to 140 feet at Waycross; and along the third a descent from 206 feet at Baxley to 155 feet at Odum.

The northern part of Effingham and the southern parts of Screven and Bulloch counties also present the aspect of a plain similar to the Okefenokee plain.

COLUMBIA GROUP.

OKEFENOKEE FORMATION.

Distribution and character.—The name Okefenokee is derived from Okefenokee Swamp, a great, swampy tract in southern Georgia covering parts of Charlton, Ware, and Clinch counties. The swamp occupies a portion of the plain on which were laid down the deposits under consideration. The Okefenokee formation consists in part of coastal terrace deposits and in part of river terrace or fluviatile deposits. During its deposition there was probably a depression of the land, the coast line being perhaps 40 to 75 miles west of its present

position. Coastal sands and probably other sediments were laid down as a terrace, and contemporaneous fluviatile terraces were formed along the larger rivers as far as the fall line. The coastal terrace formed during this period is a flat plain 20 to 40 miles wide, which varies in elevation from 60 to about 125 feet above sea level and is covered with gray and white quartz sands. The river terraces lie 50 to 100 feet above low-water level and form prominent topographic features along Savannah, Ocmulgee, and Chattahoochee rivers. The river-terrace deposits consist of sands and gravels of fluviatile or fluvioestuarine origin. The two types of deposits will be described separately.

Coastal terrace deposits.—The coastal terrace phase of the formation is represented principally by a thin deposit of gray sand which covers the Okefenokee plain. The age of the formation is determined by its physiographic position and not by fossils, for none of these have been found. The western boundary of the plain is marked approximately by a line extending from near Sisters Ferry on Savannah River, or Clyo, southeastward through the northern part of Bryan County, to about 3 miles north of Ludowici, Liberty County; thence to Jesup, and along the Atlantic Coast Line Railroad to near Waycross, Ware County; and thence to the western boundary of the Okefenokee Swamp. The plain includes the Okefenokee Swamp and the towns of Folkston, Jesup, Ludowici, and Hinesville. Its eastern boundary is marked by an escarpment 20 to 40 miles from the coast, which separates it from the first or Satilla terrace. (See fig. 1, p. 29.)

The most conspicuous deposit on the plain referable to this period is gray sand. Red and yellow sands containing thin clay layers and pebble beds underlie the surface sand and are doubtless in part Pleistocene. The marine terrace deposits of the Okefenokee formation are not in contact with any formation older than Pliocene and Miocene. On the west the sand of the Okefenokee plain merges into the surficial sand of a higher plain, and the two can not everywhere be sharply discriminated. Swampy flats traversed by small creeks and underlain by muds probably belonging to this epoch of the Pleistocene occur in the plain.

The gray surface sand is composed almost entirely of subangular quartz particles, probably derived from the older formations of the Coastal Plain. On the whole, the sand is perhaps finer in texture and lighter in color than the upland sands to the west. At the surface it is loose, incoherent, and structureless, but in depth it shows faint lines of stratification and current bedding. At a few localities it is white at the surface and darker colored beneath, the white phase having been formed by leaching and not as a separate deposit. A notable occurrence of white sand lies along the railroad between Ludowici and Darien Junction.

In the Okefenokee Swamp the only deposits known, aside from the recent peaty accumulations, are white, yellow, brown, and black sands—the dark colors being due to organic matter. The sand is in places indurated, probably by a cement of iron oxide. This is the so-called hardpan of this area.

The thickness of the sand is small, probably averaging less than 10 feet over the whole plain. Good exposures appear at Folkston, where the average thickness is 6 or 8 feet, with local accumulations reaching 20 feet; the sand is gray, almost white at the surface, and light yellow beneath. At other places over the plain its thickness varies from 2 to 15 feet.

The plain which the Okefenokee covers is in general flat and almost featureless. Some of the larger streams traversing the plain have bluffs 30 or 40 feet high, but these are exceptional. The erosive power of rain water is lessened by the porous sand, and ravines and gullies are rare. The main streams have few tributaries. The plain is dotted with cypress ponds and swamps due to original inequalities in the land surface. Locally the sand has been heaped into low ridges and hills, some of which may have been factors in determining the courses of streams.

As may be inferred from the lithologic description given above little can be said regarding the structure of this formation. It conforms to the low seaward slope of the Okefenokee plain and varies in elevation from 60 to 125 feet above sea level.

Fluviatile terrace deposits.—Bordering the large rivers of the Coastal Plain of Georgia are remnants of a plain higher than the "second bottoms" or Satilla plain and 50 to 200 feet lower than the general upland of the region. It is believed that the deposits laid down on this plain are contemporaneous with the coastal deposits of the Okefenokee formation. While the coastal portion of the Okefenokee terrace plain was being cut and the gray sands and other deposits were being laid down upon it, the terraces bordering the present river valleys and their accompanying deposits were being formed, either by the waves along the borders of reentrant estuaries, or by the meandering of the rivers in the parts of the valleys not submerged. The river terraces coalesce with the coastal terrace.

The river-terrace plains lie 50 to 125 feet above the present rivers. Immediately subsequent to their formation the fluviatile portions of the Okefenokee plain filled the valleys from side to side, having widths varying from 1 to 10 miles; into these ancient plains the rivers have intrenched themselves, forming younger plains at the levels of the Satilla plain and of the Recent flood plain. The cutting of these younger plains has destroyed all but remnants of the original Okefenokee plain.

The fluviatile deposits of the Okefenokee formation overlie in turn all the older formations of the Coastal Plain, from the Cretaceous to the Pliocene. The materials have been derived in part, perhaps chiefly, from these older formations, and in part from the rocks of the Piedmont Plateau north of the Coastal Plain. On account of lithologic similarity it is in places difficult to distinguish between the terrace deposits and the underlying older formations. However, a gravel bed is generally present at the base of the terrace deposits, and unconformable relations to the older deposits appear wherever there are clean-cut exposures.

The deposits consist chiefly of red argillaceous sands, in places pebbly, and coarse gravels. (See Pl. XVII, *A*.) Clay beds are few and the formation lacks the distinctive alluvial character of the lower terrace and flood-plain deposits. Along some of the streams a gray, incoherent, rather pure sand seems to be the only deposit. Near the fall line the deposits show clearly that they have been derived in large part from the crystalline rocks of the Piedmont Plateau, but farther south the formations of the Coastal Plain have contributed a major portion of the materials. Along Withlacoochee, Alapaha, and Ochlockonee rivers the detritus has been derived entirely from the formations of the Coastal Plain. The formation is usually unconsolidated, but at a few places contains local beds of gravel cemented by iron oxide. The pebbles are chiefly quartz and quartzite, but a subordinate percentage are limestone, flint, and limonite.

At a number of localities on the Okefenokee plain there are surficial, brown-gray, loose, incoherent sands which differ in their physical appearance and lithologic characters from the red loams and gravels forming the terrace deposits, and which resemble closely the gray sand of the upland. Conspicuous accumulations of such sands were noted at Montezuma, Bainbridge, Fort Gaines, Dublin, and Lumber City. (See Pl. XVII, *B*.) Some of these deposits are in the form of hills and are probably of wind-dune origin; they may have been formed subsequent to the elevation of the terrace plain. At other localities the gray sands appear to be water-laid sediments which rest directly upon the older formations, forming a thin uniform mantle over the plain.

The formation is thin, not exceeding 50 feet in thickness at any place and being usually much less than 20 feet. The greatest thickness was noted near the fall line.

Except for fragments of silicified wood found at Fort Gaines and for fossils in limestone and flint pebbles derived from the underlying Tertiary beds no fossils are known in this formation.

The deposits are confined to comparatively level plains paralleling the rivers. The plains were originally 1 mile to 10 miles in width, but the deposits have been so largely removed by subsequent erosion

A. EXPOSURE OF PLEISTOCENE TERRACE GRAVEL (OKEFENOKEE FORMATION) IN COLUMBUS-LUMPKIN ROAD, CHATTAHOOCHEE COUNTY, 11 MILES SOUTH OF COLUMBUS.

B. SAND USED IN THE MANUFACTURE OF GLASS (PROBABLY BELONGING TO THE OKEFENOKEE FORMATION), 2 MILES NORTHEAST OF LUMBER CITY, ON THE NORTH SIDE OF LITTLE OCMULGEE RIVER.

that their total area is relatively small. They are confined principally to the courses of Chattahoochee, Flint, Ocmulgee, Oconee, Altamaha, Ogeechee, Savannah, Ochlockonee, Withlacoochee, Little, and Alapaha rivers.

At a few localities the terrace forms conspicuous topographic features. The business portion of Macon, a part of the residence portion of Columbus, the cities of Fort Gaines, Albany, Lumber City, and parts of Augusta are built on this terrace.

In detail the surface of the terrace is nearly level, the only undulations being due to sand heaps. The vegetation is more luxuriant and the soil generally more fertile than on the interstream uplands.

The approximate elevations of the second or Okefenokee terrace plain above sea level at the fall line are:

Elevations on Okefenokee terrace plain at fall line.

	River.	Terrace plain.
	Feet.	*Feet.*
Augusta	98	200
Milledgeville	215	290
Macon	279	355
Flint River at fall line	320?	380?
Columbus	190	300 to 325

From the fall line the river terraces gradually descend and merge into the coastal sand plains bordering the seacoast.

SATILLA FORMATION.

Deposition.—The name Satilla is derived from Satilla River, Ga., and is applied to the latest Pleistocene deposits of the State. These deposits are typically developed along either side of Satilla River in Camden and Charlton counties. The shore line during their deposition was parallel to the present Atlantic coast, but stood 20 to 30 miles farther inland. The greater parts of Camden, Glynn, and Chatham counties, all of McIntosh County, the southern part of Bryan County, and the eastern part of Liberty County were submerged and the valleys of the larger rivers were inundated to undetermined distances inland. Two types of deposits, coastal marine deposits and fluviatile or river terrace deposits, were formed.

Coastal terrace deposits.—The coastal deposits lie upon a wave-cut terrace which extends 20 to 30 miles back from the present ocean at elevations of 15 to 40 feet above sea level. The western limit of this terrace or plain is marked by the high sand ridge east of Folkston, Charlton County, and by the escarpment at Waynesville and Mount Pleasant, Wayne County, and at Walthoursville, Liberty County. North of Liberty County the escarpment is not so pronounced as it is to the southward, and owing to the lack of topographic maps it

has not been traced in detail; however, it probably passes close to Clyde, Bryan County, Meldrim, Effingham County, and Meinhard, Chatham County. This terrace is referred to in this report as the "first marine terrace" or "first Pleistocene plain" and is not to be confused with the Recent analogous plain now in process of formation as sand beaches and tide marshes.

The deposits on the Satilla plain rest unconformably upon Pliocene or Miocene strata, concealing the latter from view except where exposed along stream bluffs and banks. No sharp distinction can be drawn between the latest Pleistocene and the Recent deposits.

The relative age of the formation with respect to the older Okefenokee formation is determined by its topographic position and not by its stratigraphic sequence or its paleontologic character.

The formation consists of greenish and bluish marine clays; gray, white, and yellow sands; and thin layers of gravel. None of the deposits are consolidated.

The clays are fine textured and appear to have been deposited as muds in lagoons or tidal marshes. They are calcareous in places and contain oyster shells and white calcareous nodules, disseminated, decayed vegetation, stumps of trees, and bones of animals. Gypsum crystals were noted at Savannah and at Colerain Bluff on St. Marys River in Camden County. The clays are usually massive and show few traces of lamination or bedding. They are underlain by sands and often by thin beds of well-rounded quartz pebbles, apparently of beach origin. The sands cover the greater part of the plain and form low bluffs on the coast. At the surface they are gray or white, becoming yellowish, brownish, or even black at depths, the color being due to iron oxide and disseminated organic matter. They are composed almost entirely of sharp, angular, quartz grains, and are perhaps, on the whole, finer than the gray, surficial sands of the higher plains; small amounts of mica and black sand, magnetite, ilmenite, and other black, silicate minerals were noted. The sands show evidences of stratification and cross-bedding, and contain shells or prints of shells; at a few places, as at the bluff near Crescent, McIntosh County, they are slightly indurated by iron-oxide cement.

The sands and clays are closely associated and are contemporaneous deposits.

The maximum thickness of the deposits is perhaps not more than 50 feet and the average not more than 15 feet. A thickness of 22 feet of clay has been observed near Savannah and 20 feet of sand appears at Crescent. At Rose Bluff, Fla., opposite St. Marys, the bluff, which at low tide is 45 feet high, exposes Pleistocene strata referable to this formation from base to top.

The formation is fossiliferous and in this respect is in contrast to the older and topographically higher Okefenokee formation. Shells,

mostly living species, are common in places; remains of mammals, including megatherium, tapir, horse, mammoth, beaver, deer, and cetacea, sharks' teeth, and the remains of a species of crocodile are also found. Buried stumps have been observed at many places, but no other plant remains of paleontologic value have been discovered.

Bones and teeth obtained from the dredgings at Brunswick were studied by J. W. Gidley, of the Smithsonian Institution, who says:

> The materials from Brunswick, Ga., consist for the most part of fossil fragments of various mammals and fishes representing species of early Pleistocene age. The sharks' teeth, however, probably represent Eocene and Miocene species. The recognizable genera and species are as follows:

MAMMALS.

Equus fraternus Leidy.
Equus? complicatus Leidy.
Equus? tau Owen (or more probably an undescribed species).
Mammut floridanum (Leidy).
Physeter? vetus Leidy or Physeterula? neolassicus.
Megatherium sp. probably M. americanum.
Castoroides ohioticus.
Bison? bison Linn.

MAMMALS—Continued.

A cervuline, probably belonging to the genus Cervus.
Tapirus haysii Leidy.

FISHES.

Carcharodon, Galeocerdo, and Lamna.
Sting-ray—Pastinaca sp.
The sharks' teeth represent several species of the genera Carcharodon, Galeocerdo, and Lamna.

REPTILES.

Crocodilus sp.

The "Eocene and Miocene species" may be detrital material redeposited during the Pleistocene.

A collection of shells was made at Rose Bluff, Fla., opposite St. Marys, Camden County, from which the following forms were determined by T. W. Vaughan:

Mulinia lateralis (Say).
Terebra dislocata Say.
Olivella mutica Say.
Nassa acuta Say.
Turbonilla sp.
Neverita duplicata Say.
Natica pusilla Say.
Sigaretus perspectivus Say.
Nucula proxima Say.
Arca incongrua Say.
Ostrea virginica Gmel.
Anomia sumplex Orb.
Phacoides multilineatus (T. & H.).
Divaricella quadrisulcata Orb.
Cardium robustum Solander.
Tellina (Angulus) sayi Deshayes.
Strigilla flexuosa Say.
Donax fossor Say.
Donax variabilis Say? young.
Ervilia concentrica Gould.
Labiosa canaliculata Say.

Sir Charles Lyell,[1] who visited several localities along the coast of Georgia, notes finding the tooth of a Mylodon and the grinder of a mastodon at Heyners Bridge, 12 miles south of Savannah; he also mentions finding the remains of Megatherium in the old Brunswick Canal and on Skidaway Island. Lyell suggests that the deposits are

[1] Travels in North America, vol. 1, pp. 163, 164, 1845.

of fluviomarine origin and that the bones of the mammals were carried down by streams.

Oyster shells are found in the clay deposits west of Savannah, in clay in the western part of Glynn County, in the clay terrace bordering St. Marys River, and elsewhere. Large bones of mammals have been found at Whiteoak, Camden County.

The time that has elapsed since the emergence of the Satilla plain from below sea level has been relatively short and erosion has affected only slightly the appearance of the surface. The plain is very flat and comprises great stretches of swamp land. In places on the plain there are low ridges of sand, probably of beach and wind-dune origin, although some such ridges may have existed as banks or islands previous to the emergence of the plain above sea level. The clay flats probably represent the sites of old marshes and shallow estuaries and straits.

If the coast region were uplifted 15 or 20 feet above its present elevation, a plain now submerged beneath the ocean waters would appear as an emerged terrace lying east of and parallel to the Satilla terrace and separated from it by an escarpment. This plain would be analogous to the Satilla plain in all its essential features.

Fluviatile terrace deposits.—The fluviatile deposits of the epoch form low terraces along the larger rivers of the Coastal Plain. They consist of unconsolidated sands, clays, and gravels which merge coastward into the marine or fluviomarine deposits.

The river terraces of the Satilla formation are comparatively flat plains, lying 10 to 50 feet above the rivers and varying in width from a few yards to 10 miles. They extend from the fall line southward and eventually merge into the marine terrace plain of the same formation. The greatest width is along the lower course of Savannah River, but the river is cutting into this original terrace and forming the recent alluvium. A distinction is made between the Satilla terrace and the Recent flood plain.

The Satilla formation overlies Cretaceous and Tertiary formations unconformably. It varies in elevation above sea level from about 300 feet at the fall line to 20 or 30 feet where it merges into the coastal deposits. Its thickness does not generally exceed 10 or 20 feet but attains 40 feet in places.

Lithologically the deposits vary considerably on the different rivers. On the whole they are distinctly fluviatile or alluvial, consisting of clay (Pl. XVI, *B*, p. 100), sands, and gravels, generally unconsolidated, and without regular bedding. The materials have been derived in part from the adjacent older formations of the Coastal Plain, and in part from the rocks of the Piedmont Plateau to the northward. Sand heaps, probably wind accumulations, were noted at a number of places on this terrace.

The river-terrace deposits contain little of paleontologic interest. A few mammalian bones were found at the base of the deposits on St. Marys and Suwannee rivers, and a few fragments of silicified wood have been observed.

RECENT SERIES.

The Recent deposits, or those formed since the close of the Pleistocene or the uplift of the Satilla or latest Pleistocene terrace and now in the process of formation, consist of (1) marsh and tide-swamp muds; (2) beach and dune sands; (3) river flood-plain deposits; (4) interstream swamp deposits; (5) certain terrigenous deposits semi-alluvial in character.

The processes by which the Satilla terrace, with its accompanying deposits, was formed are being repeated at the present time along the coast. The Recent terrace thus being formed is largely submarine. Beach sands are being laid down on the ocean front, sands and clays are being deposited in the estuaries, and muds are being deposited in the marsh and tide-swamp lands. In the absence of accurate maps the area of marsh and tide-swamp land along the coast may be roughly estimated at 400 square miles. Though observations have not been made at many localities, it may be said that the thickness of the Recent deposits in the area inundated by the tides probably does not exceed 6 feet. The composition of the muds is indicated by the following analysis of a sample from St. Simons Island, collected by S. W. McCallie and analyzed by Edgar Everhart.

Analysis of mud from St. Simons Island.

Moisture at 100° C	4.62
Loss on ignition	9.94
Soda (Na_2O)	3.06
Potash (K_2O)	1.13
Lime (CaO)	.40
Magnesia (MgO)	1.28
Alumina (Al_2O_3)	13.67
Ferric oxide (Fe_2O_3)	4.86
Titanium dioxide (TiO_2)	1.01
Sulphur trioxide (SO_3)	.24
Phosphorus pentoxide (P_2O_5)	.22
Chlorine (Cl)	1.77
Silica (SiO_2)	57.95
	100.15

In places the Satilla terrace is separated from the Recent terrace by bluffs 10 to 15 feet high, and at other localities the two merge into each other.

The Recent alluvium along the Coastal Plain streams consists mainly of sand, although along the lower courses of Altamaha and Savannah rivers some clays are being deposited. The deposits of

this class are of small extent; along some of the streams the only Recent deposits are accumulations of sand in the form of bars.

In the southeastern part of the Coastal Plain of Georgia are numerous swamps ranging in size from a single acre to the immense tract known as Okefenokee Swamp. Peaty accumulations or decayed plant matter with more or less silt and sand are being formed in these swamps. In the Okefenokee Swamp accumulations of peat 4 feet thick have been observed. Some of the swamp areas are densely wooded and have been the roosting places of birds for perhaps centuries, and a phosphatic muck is being slowly formed from their dung and dead bodies.

Sand deltas or plains of semialluvial character form another type of Recent deposits. In the northern, hilly part of the Coastal Plain erosion has been very active because of the loose, unconsolidated character of the formations; and at certain localities, especially where the forests have been cut away, deep gullies have been formed. Every torrential rain moves large quantities of sand which, on account of overloading, is deposited along the beds of the small creeks, forming so-called "sand streams," or is spread out at the mouths of gullies, forming small subaerial deltas. The best example of this type is at the huge gullies or "caves" west or Lumpkin, Stewart County.

SURFICIAL GRAY SANDS OF THE UPLAND.

Surficial grayish or brownish, incoherent quartz sands cover large portions of the interstream uplands of the Coastal Plain of Georgia at elevations higher than the Pleistocene terrace plains. Because of the sterility of the soils which these sands produce and their influence on the topography and tree growth, they attract the attention even of those not interested in geology. The sands are not everywhere of the same origin. Much of the sand is residual and can not be referred to any one geologic period or formation. However, in places there are wind-blown accumulations, and at long intervals marks of stratification can be detected. In this report no attempt has been made to subdivide or to map these sands; a part of such mapping, indeed, would fall within the province of a soil survey.

The gray sands are of particular importance owing to their efficacy in checking rapid run-off and in absorbing rainfall and by this means increasing the underground-water supplies. They consist chiefly of crystalline quartz and nowhere contain sufficient clay to render them coherent. A number of samples were examined microscopically and were found to contain, in addition to the quartz grains, small percentages of clay, some limonite and allied iron-oxide minerals, and very small amounts of minerals such as mica, magnetite, ilmenite, feldspar, and rutile that are common to igneous rocks. The clay content rarely exceeds 3 per cent; the limonite occurs as a coating

over the quartz grains and in places gives the sand a yellowish or brownish appearance.

On the whole, the gray sands are uniformly fine in texture. Sands from several localities each passed 40 to 60 per cent through a 40-mesh sieve, their texture at any particular locality depending on the character of the formations from which they were derived. In all of the more notable deposits the quartz grains are for the most part subangular. In color the sands are dull gray or white at the surface, but at varying depths they become yellowish or darker, and the darker basal sands grade downward into the underlying unweathered, argillaceous, sandy formations. Pebbles are not common, though small well-rounded to angular quartz pebbles, and small brown or black iron-oxide nodules were observed at several localities. Notwithstanding the diverse origin and the slight differences that have been noted from place to place, the sands are in the main uniform in texture, color, and composition.

In thickness the gray sands range from a few inches to a maximum of 30 feet. Their greatest thickness where apparently residual occurs at the sand pits near Howard, Taylor County, the maximum being 30 feet. At other localities along the fall line 10 to 25 feet of sand has been observed, but over much of the sand-hill region the thickness does not exceed 5 to 6 feet. Over the Alum Bluff formation and later Oligocene beds the average depth of the sands where residual is probably 2 to 4 feet, but there are local accumulations of torrential or eolian origin that reach 10 to 25 feet. In the western part of the Coastal Plain, principally in the part underlain by the Vicksburg formation, and in scattered smaller areas in other parts of the upland region, the gray sands are either absent or very thin.

The surficial sands are present as a thin mantle over parts of the upland region from the fall line on the north to the Florida State line on the south. To the southeast, within 50 or 75 miles of the Atlantic coast, they merge into the lithologically similar sands which cover the Okefenokee terrace plain. The sands are unequally distributed over the upland and are notably absent from certain areas. Their most conspicuous development is in the region of the fall line, chiefly over the area underlain by Lower Cretaceous strata; they are also well developed over the region underlain by the Alum Bluff formation and later Oligocene beds in the eastern and southeastern parts of the Coastal Plain. Among upland areas, where the sands are nearly or entirely absent, are certain areas in Burke, Washington, Wilkinson, and Twiggs counties which are underlain by red ferruginous sands of the Claiborne formation; Rich Hill, Crawford County; the upland plain in the vicinity of Fort Valley and the "red lands" in the vicinity of Grovania, Henderson, and Elko, in Houston

County; the northern part of Dooly County; areas near Americus and in the southern part of Sumter County; large parts of Randolph, Terrell, Dougherty, and other counties west of Flint River; and areas in the southern parts of Grady, Thomas, and Brooks counties.

The sands, notwithstanding their relatively insignificant thickness, have had a very marked influence upon the topography, vegetation, and agricultural development of the country. The "sand hills" constitute a well-known type of topography in the region of the fall line and throughout the area underlain by the Alum Bluff formation and later Oligocene beds, popularly known as the "wire-grass" region. In the latter region conspicuous accumulations of sand 10 to 30 feet thick occur along the streams and particularly along those streams having general north-south courses. It has been commonly noted by the people living in this region that these accumulations are greater on the east or left sides of the streams. Numerous exceptions to this may be found in the Coastal Plain region as a whole, but it is prevailingly true over the "wire-grass" region. The hills perhaps antedate the present streams. The most notable examples of this type of sand hills are on the eastern side of Ohoopee River at Reidsville, on Canoochee River at Stillmore, on Little Ocmulgee River 2 miles east of Helena, at Lumber City, east of Oconee River at Dublin, and on the north side of Satilla River north of Waycross. These hills are well above the level of the streams and the sand is not to be confused with the alluvial sands of lower levels. The vegetable growth over the sand hills is sparse, consisting mainly of scattered long-leaf pine and stunted oak, and the soil is poor and unproductive.

In the few references made by McGee[1] to the gray surficial sands he referred them to the "interfluvial phase of the Columbia." Spencer,[2] McCallie,[3] and Otto Veatch[4] have referred to them in a general way as "Columbia sand." R. M. Harper[5] has given interesting descriptions of the sands at a number of localities, discussing them with reference to their influence on the flora of the Coastal Plain.

It is reasonably certain that much of the surficial sand is residual from Cretaceous and Tertiary formations, and hence should not be classed as a formation, using this word in a stratigraphic sense. The residual sands vary from 1 to 10 feet in thickness. On the slopes at many places there are accumulations of sands transported by rain water from higher to lower levels, and some of these appear to rest unconformably upon the underlying strata, this relation being especially apparent where pebbles are present at the base. Such

[1] The Lafayette formation: U. S. Geol. Survey Twelfth Ann. Rept., pt. 1, pp. 388, 389, 1891.
[2] Spencer, J. W., Georgia Geol. Survey First Rept. Progress, pp. 61–71, 1891.
[3] McCallie, S. W., Underground waters of Georgia: Georgia Geol. Survey Bull. 15, p. 29, 1908.
[4] Clay deposits of Georgia: Georgia Geol. Survey Bull. 18, p. 68, 1909.
[5] A phytogeographical sketch of the Altamaha grit region of Georgia: New York Acad. Sci. Annals, vol. 17, pt. 1, 1906.

deposits may show a thickness of 5 to 15 feet whereas the residual sands on the tops of the hills may not be more than 2 feet. Accumulations of this nature are properly colluvial deposits. The winds may in places have shifted and redeposited the residual sands, but do not appear to have been the cause of many large deposits.

The formations from which the residual surficial sands are derived are themselves composed chiefly of quartz sand with small percentages of disseminated clay. In the process of weathering the clays are carried away in suspension by rainfall, and the quartz grains and small amounts of other minerals, such as mica and iron oxides, are left. Wherever the formations underlying the surface are very calcareous, argillaceous, or ferruginous, the gray surficial sands are absent.

The origin of the accumulations of sand along Canoochee, Ohoopee, Little Ocmulgee, and Satilla rivers, and along other streams throughout the Altamaha upland or wire-grass country has not been determined with certainty. These accumulations appear to be at higher elevations than the fluviatile terrace deposits of the Okefenokee formation. Locally, they exhibit faint stratification and in places seem to be sharply separated from the underlying older formations. These facts, together with their peculiar distribution and relatively great thickness, are evidence of their nonresidual character. Their high elevation precludes the possibility of their having been deposited by existing streams. It is suggested that they may have been heaped up as the result of combined wave and wind action along the shores of early Pleistocene estuaries, or they may have been deposited as alluvium by the rivers occupying the valleys in early Pleistocene time.

One well-known sand deposit—the sand hills on the east side of Flint River at Albany—clearly owes its present form to wind deposition, whatever may have been the primary origin of the sand.

There is some evidence of the existence of a sand-covered Pleistocene terrace plain higher and older than the Okefenokee plain and perhaps similar in origin, but as yet sufficient proof of its existence has not been obtained to warrant positive statements. Such a plain, if it exists, includes a part of the gray surficial sands here treated under the head of upland sands. (See p. 103.)

WATER SUPPLY.

SOURCE AND AMOUNT.

The primary source of water supply is rainfall. The average annual rainfall ranges from 43 to 55 inches in different parts of the Coastal Plain of Georgia, as shown by the following record of observations by the United States Weather Bureau to the year 1908:

Mean annual rainfall in the Coastal Plain of Georgia to 1908.

Locality.	Rainfall.	Locality.	Rainfall.	Locality.	Rainfall.
	Inches.		*Inches.*		*Inches.*
Abbeville	46.09	Eastman	43.72	Millen	45.25
Albany	49.28	Fitzgerald	49.37	Morgan	52.17
Alapaha	47.57	Fleming	55.51	Piscola	51.40
Allentown	49.85	Fort Gaines	51.13	Poulan	51.14
Americus	48.84	Harrison	47.68	Putnam	49.39
Augusta	46.94	Hawkinsville	48.63	Quitman	52.48
Bainbridge	49.90	Hephzibah	44.71	St. Marys	52.57
Blakely	55.23	Jesup	51.03	Savannah	50.06
Brag	53.35	Louisville	46.41	Statesboro	49.48
Brunswick	49.63	Lumpkin	49.81	Talbotton	52.62
Butler	52.12	Macon	47.51	Thomasville	53.01
Columbus	50.70	Marshallville	50.91	Valona	47.79
Dublin	47.33	Milledgeville	47.77	Waycross	44.99
Dudley	46.93				

If an average of 49 inches is assumed, the annual rainfall is equivalent to the enormous amount of 852,000,000 gallons per square mile.

DISPOSITION.

A portion of the rainfall escapes as direct surface run-off, supplying in part the waters of creeks and rivers; a portion is taken up by evaporation and by vegetation; a small portion enters into chemical combination and is locked up in minerals, and the remainder is held by the earth for a shorter or longer time as the underground-water supply.

RUN-OFF.

The amount of water which flows from any particular land area by streams depends mainly on the topography, the character of the geologic formations, the vegetation, the nature of the precipitation (whether slow or torrential), and to an appreciable extent on artificial structures such as buildings, pavements, and roads.

To illustrate the influence of topography two extremely different topographic regions of the State, the Blue Ridge and the flat lowlands of the Coastal Plain bordering the Atlantic Ocean, may be taken. In the first the creeks rise rapidly and turbulently, even after a single shower, attesting to the heavy run-off or flood flow; whereas in the coastal flats the creeks and rivers rise above their banks only after prolonged rains.

Other factors being equal, the direct run-off will be greater in a region underlain by clay or shale than in one underlain by sand or sandstone, because the former materials absorb water much less readily than the latter.

Vegetation is undoubtedly a factor, for in a forest area roots of trees and vegetable mold prevent rapid run-off. Leaves and branches of trees convert rain into spray and lessen its impact, thereby becoming a factor in increasing the amount of rainfall absorbed by the soil.

The breaking up of the soil by cultivation renders it more porous and increases absorption and decreases run-off.

Streams derive their waters in part from direct run-off or flood-flow and in part from springs. According to estimates by the United States Geological Survey approximately two-fifths (40 per cent) of the total rainfall of the Coastal Plain of Georgia reaches the ocean in the form of run-off. The percentage of the direct run-off or flood flow to the total run-off is not known, but it probably does not exceed 10 or 15 per cent; in other words, the greater part of the run-off is drawn from the underground water and supplied to the streams through springs. The bulk of the underground waters consists, therefore, of waters temporarily checked in their passage to the sea.

EVAPORATION.

Evaporation takes place mainly from the soil, from running water, and from lakes and ponds. A comparatively small although not negligible amount of water is evaporated before entering the earth; this includes not only the water evaporated from the surface of the ground, but that which is caught by leaves and branches of trees, by roofs of buildings, and by other artificial structures. The amount of the rainfall evaporated depends mainly on climatic conditions; if in the Coastal Plain of Georgia 40 per cent of the total rainfall reaches the ocean as run-off and less than 1 per cent enters into chemical combination with minerals, then nearly 60 per cent is evaporated, either directly or indirectly.

VEGETATION.

In the aggregate vegetation takes up an enormous amount of water, which is eventually evaporated and so lost to the underground supply. Estimates have been made showing that only 70 per cent as much rainfall reaches the soil in a wooded area as in open fields, and measurements have been made showing that the amount of water at depths of 16 and 32 inches is appreciably greater in a bare than in a forested soil.[1]

CHEMICAL ABSORPTION.

A small percentage of the waters absorbed by the earth enters into chemical combination with the rocks. For example, in the conversion of hematite (Fe_2O_3) into limonite ($2Fe_2O_3$, $3H_2O$) 14.5 per cent of water is absorbed.

Van Hise,[2] in a generalized statement, says that at least 99 per cent of the water entering the earth returns in some form to the surface, and it is inferred that the remaining 1 per cent or less enters into combination with the rocks.

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[1] U. S. Dept. Agr. Forestry Div. Bull. 7, p. —, 1893.

[2] Van Hise, C. R., A treatise on metamorphism: U. S. Geol. Survey Mon. 47, p. 156, 1904.

UNDERGROUND-WATER STORAGE.

The amount of the rainfall absorbed by the soil and by the rocks in the Coastal Plain of Georgia is roughly estimated to be 90 or 95 per cent of the total, the climate, topography, character of the soil, and other factors being taken into consideration. If nearly 60 per cent of the rainfall is lost by evaporation, and 4 or 5 per cent escapes as direct run-off or flood flow, only about 35 per cent remains to form the underground-water supply. All of this, even, is not available for use on account of the great depths to which much of it descends and the fact that a large part of it is locked up in fine-grained compact strata which do not readily yield their waters to the wells tapping them.

SURFACE WATERS.

STREAMS.

Surface streams of the Coastal Plain of Georgia are not extensively used as sources of municipal supplies except in a narrow area along the northern border, cheaper and more healthful waters being obtainable from deep wells. Augusta and Macon obtain their water supplies from Savannah and Ocmulgee rivers, respectively, these cities being located on the northern boundary of the Coastal Plain where it is not possible to obtain adequate supplies of artesian water unless the pumping plants are located several miles from the city limits. Columbus at present obtains its water supply in part from Chattahoochee River and in part from springs west of the river in Alabama. Milledgeville, the county seat of Baldwin County, is located on the fall line and obtains its municipal water supply from Fishing Creek. Perry, the county seat of Houston County, obtains its water supply from Big Indian Creek.

In the southern and southeastern parts of the Coastal Plain the waters of the streams, except those of the four largest rivers, are dark in color, owing to their high content of organic matter, but are suitable for the use of domestic animals, and are superior to most artesian waters for producing steam.

LAKES AND PONDS.

The waters of the lakes and ponds of the Coastal Plain are not used extensively for any purpose. Many of the lakes are in the river swamps and are not only inaccessible but furnish stagnant, unwholesome waters. A few lakes in the lime-sink regions are clear and appear to be connected with underground streams. Ponds are numerous in some sections; some of them contain stagnant waters or waters high in their content of organic matter. Such waters are used to some extent for stock and boiler supply.

UNDERGROUND WATERS.

WATER TABLE.

As water percolates downward from the surface it reaches a level where the soils, sediments, or rocks are saturated. This upper limit of saturation is known as the water table. The depth to this level differs from place to place according to the topography and the texture and porosity of the rocks and from time to time according to the rainfall. Shallow wells are generally sunk only a few feet below the water table; springs of the common type occur at points where the water table intercepts the surface. In the Coastal Plain the water table varies in position from the surface to 50 feet or more beneath it.

Although the materials below the water table are all saturated, all of them do not yield their contained waters with equal readiness to the wells tapping them. In stratified rocks some beds are extremely coarse and porous and allow waters to circulate freely through them; others are compact and relatively though not absolutely impervious. Between the two extremes are all gradations of porosity. (See also pp. 120–122.)

QUALITY OF WATER.

The portion of the rainfall which is absorbed by the earth percolates through the soils, sediments, and rocks, and takes into solution greater or less amounts of the soluble salts with which it comes into contact. All underground waters are therefore in a sense "mineral waters," although the term is frequently used for waters having medicinal properties due to certain mineral constituents held in solution.

The amount and nature of the mineral constituents in underground water depends on a number of variable factors, but mainly on the character of the rock strata through which it has circulated.

In addition to inorganic matter held in solution underground waters may also carry in suspension mineral matter such as clay, fine mica, and precipitates of iron oxide. Shallow-well waters and spring waters are more likely to contain sediments than deep-well waters.

Organic matter may be present, especially in the waters of shallow wells unprotected from surface drainage or located in low swampy places and in springs located in swamps or unprotected from falling leaves, twigs, and other refuse. Vegetable matter may also be present in the waters of deep wells which, although protected from surface contamination, penetrate beds containing lignite; organic matter from this source, however, is comparatively rare and is not injurious to the health.

A detailed discussion of the quality of the waters of the State, by R. B. Dole, is given on pages 470–532.

ARTESIAN WATERS.

DEFINITION.

The term "artesian," as here used and as adopted by the United States Geological Survey,[1] applies to wells the waters of which are under hydrostatic pressure and rise above the level at which they are encountered, but which do not necessarily rise to or above the surface of the ground. The term may therefore be applied to either flowing or nonflowing wells. By many persons the term "artesian well" is understood to mean a well which flows at the surface, but the definition just given is preferable, because it is based on hydrostatic pressure, and because wells tapping the same water-bearing stratum may be either flowing or nonflowing according to the elevation of the surface of the ground at their respective sites.

IMPORTANCE.

Artesian water is of vital interest to the people inhabiting the Coastal Plain of Georgia, for without artesian wells many of the small towns and communities would be without adequate healthful supplies. All the cities, except those located near the fall line, and all the more progressive towns and villages obtain their public water supplies from artesian wells. Wells are continually being drilled on plantations, and they afford waters suitable for drinking and for most ordinary purposes. Such waters might be used, particularly where flows can be obtained, for irrigation, although this has been attempted on only a small scale. An account of the large returns from 14 acres of land in Dougherty County irrigated from an artesian well is given on page 239.

CONTROLLING CONDITIONS.

The following requisite conditions for artesian wells were enumerated by Chamberlin[2] in 1885:

A pervious stratum to permit the entrance and the passage of the water.

A water-tight bed below to prevent the escape of the water downward.

A like impervious bed above to prevent escape upward, for the water, being under pressure from the fountain head, would otherwise find relief in that direction.

An inclination of these beds, so that the edge at which the waters enter will be higher than the surface at the well.

A suitable exposure of the edge of the porous stratum, so that it may take in a sufficient supply of water.

An adequate rainfall to furnish this supply.

An absence of any escape for the water at a lower level than the surface at the well.

This enumeration has met with general recognition and adoption, but in the extensive investigations of underground water carried on

[1] Fuller, M. L., Significance of the term "artesian": U. S. Geol. Survey Water-Supply Paper 160, pp. 7–15, 1906.

[2] Chamberlin, T. C., The requisite and qualifying conditions of artesian wells: U. S. Geol. Survey Fifth Ann. Rept., pp. 134–135, 1885.

water in the higher part of the layer produces hydrostatic pressure in the water confined in the lower part. Layer *b* is a bed of porous sand confined above and below by relatively impervious clay and pinching out down the dip between the beds of clay; hydrostatic pressure is produced in the same manner as in layer *a*. Layer *c* presents the same conditions except that the downward circulation of the water is prevented by the merging of the porous sand down the dip into relatively impervious clay. Layer *d* is a cavernous, water-bearing limestone confined above and below by relatively impervious layers and becoming noncavernous and compact down the dip. Layer *e* is a bed of porous sand in which the only hindrance to the passage of the water down the dip is friction, which causes a certain amount of hydrostatic pressure to be developed.

When a well is drilled to a bed containing water under hydrostatic pressure the water immediately rises within the well to the level at which the pressure is compensated, or, if this level is higher than the

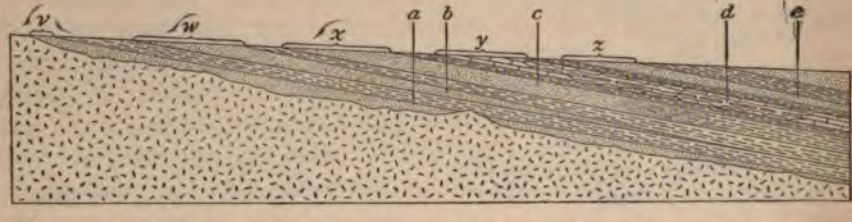


FIGURE 3.—Section illustrating the more important conditions governing artesian pressure in the Coastal Plain of Georgia. *a*, A pervious water-bearing bed cut off down the dip by an unconformity; *b*, a pervious water-bearing bed pinching out down the dip between two relatively impervious strata; *c*, a pervious water-bearing bed merging down the dip into relatively impervious materials; *d*, cavernous water-bearing limestones becoming noncavernous and compact down the dip and underlain and overlain by relatively impervious strata; *e*, a pervious water-bearing bed in which artesian pressure is produced by friction; *v*, *w*, *x*, *y*, *z*, catchment areas of the water-bearing beds *a*, *b*, *c*, *d*, *e*, respectively.

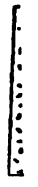
mouth of the well, till it overflows at the surface. The highest level to which artesian water will rise at any place is known as its static head at that place.

Geologic conditions are suitable for the storage of large quantities of pure artesian water at depths of 50 to 1,500 feet or more in all parts of the Coastal Plain of Georgia except in a very small area along the fall line. In this respect the Coastal Plain has a great advantage over the rest of the State.

The depths of wells in various parts of the Coastal Plain and the areas where artesian flows may be expected are shown on the map (Pl. XVIII).

NONARTESIAN WATERS.

In the Coastal Plain of Georgia most underground waters lying less than 50 to 100 feet below the surface exhibit no hydrostatic pressure and are therefore, by the definition, excluded from the class



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of artesian waters. Such waters are drawn upon by the majority of dug or driven wells.

USE OF UNDERGROUND WATERS IN THE COASTAL PLAIN OF GEORGIA.

SPRINGS.

In the Coastal Plain of Georgia springs furnish a considerable part of the domestic water supply on farms, but they are not so numerous nor so extensively used as in the other parts of the State. Lumpkin, Stewart County; Buena Vista, Marion County; Americus, Sumter County; and Columbus, Muscogee County, are the only towns which derive their public water supplies in whole or in part from springs.

A number of limestone springs in the region yield sufficient quantities of water to supply cities but have remained practically unused, chiefly on account of their location. Large limestone springs occur in Dougherty, Decatur, Worth, Baker, Webster, Crisp, Wilcox, Brooks, Laurens, Washington, Jefferson, Burke, Jenkins, and Screven counties.

SHALLOW WELLS.

The principal source of water supply in the Coastal Plain of Georgia is, at present, wells of the dug, bored, and driven types, ranging in depth from 10 to 100 feet. Such wells are constructed at small cost, for they penetrate mainly unconsolidated sands and clays with only subordinate amounts of hard rock. Commonly they yield sufficient water to meet ordinary household needs, but some of them fail in times of drought. Along the coast, however, such failure is unusual.

Waters obtained from shallow wells are generally soft and where proper precautions against surface contamination have been taken are suitable for domestic use.

ARTESIAN WELLS.

Probably between 700 and 800 artesian wells are now in use in the Coastal Plain of Georgia. They constitute the public water supplies in many towns and cities and are numerous in villages and rural districts. New wells are constantly being added to the number already in use, and the future will doubtless witness still more rapid development; indeed artesian wells will probably become the chief source of water supply.

There is no present evidence that the available supply of artesian water is decreasing in amount, but it is not improbable that, locally, the demand will in the course of time become so great as to materially lower the water table. In and adjacent to the centers of population the needless waste of artesian waters should therefore not be permitted.

Most of the artesian wells now in use range in depth from 100 to 1,000 feet and are drilled at a cost of $1 to $5 per foot, the price depending on local conditions such as the nature of the strata encountered in drilling, the depth, and other factors.

The distribution and depths of wells already drilled and the areas of probable artesian flows are shown on the map (Pl. XVIII). Detailed information is given in the table at the end of each county description.

STRATIGRAPHIC DISTRIBUTION OF UNDERGROUND WATERS.

WATER IN CRETACEOUS SYSTEM.

All the Cretaceous formations of Georgia contain water-bearing beds, but differences in texture and degree of compactness and in mineral composition render certain of them more favorable than others as sources of artesian supplies.

LOWER CRETACEOUS SERIES.

The Lower Cretaceous deposits contain abundant supplies of excellent water suitable for both domestic and industrial purposes. The numerous beds of coarse-grained sand favor the admittance of large quantities of water into the deposits, and as the beds do not outcrop to the southward the waters thus admitted can not readily escape and are kept in storage. On account of the porosity of many of the beds of sand the waters are yielded freely to the wells tapping them.

Along the northern border of the Coastal Plain adjacent to the Piedmont Plateau relatively thin Lower Cretaceous deposits overlap the crystalline rocks. Active stream erosion has greatly dissected the deposits, producing conditions that favor rapid drainage from the beds, and the quantity of water carried is therefore small. Wells located near this inner margin will generally yield water in sufficient quantities for ordinary domestic purposes but will quickly cease to yield if subjected to heavy pumping.

Away from the Piedmont-Coastal Plain border (fall line) the capacity of the deposits for carrying water increases rapidly coastward, owing to the rapid thickening of the deposits in that direction. An idea of this increased capacity may be gained from the account of the test wells drilled 3 miles southeast of the fall line at Columbus, Muscogee County. (See pp. 351–354.) Six miles or more south of the fall line the deposits will probably yield sufficient water to meet all demands for years to come.

There is, therefore, a strip of country several miles wide along the inner margin of the Coastal Plain in which the feasibility of obtaining large quantities of water for supplying the larger towns and cities from underground sources is doubtful until established by

actual test. To the south of this belt is another belt, 15 or 20 miles in width, in which practically inexhaustible supplies may be obtained from the Lower Cretaceous deposits by drilling to depths depending on the location of the well. On account of the inclination of the strata the deposits reach greater depths southward, and wells at the outer limits of the belt would have to penetrate 1,000 to 1,500 feet or more of overlying strata before reaching the water-bearing beds.

The predominance of quartz sand, clay, and kaolin as constituents of the formation, and the almost total absence of lime and iron pyrites, render the waters in general soft and low in dissolved mineral matter, especially at moderate distances from the catchment area (belt of outcrop).

UPPER CRETACEOUS SERIES.

Eutaw formation.—The irregularly bedded, loose sands which make up a considerable part of the Eutaw formation are important aquifers. The massive beds of compact sand and clay which occur in the basal part of the formation and the compact materials composing the Tombigbee sand member in the upper part are relatively impervious to water and are therefore unimportant as water bearers. Along the northern edge of the belt of outcrop the formation is thin and carries only moderate amounts of water. Farther southward the formation thickens and the quantity of the contained waters increases. From the southern edge of the outcrop southward beneath the overlying Ripley formation the terrane is an important source of artesian supply, and it may be regarded as a possible source of potable water for 5 to 20 miles. It passes to greater depths southward, and at 20 miles it lies 500 to 1,000 feet beneath the surface. The artesian wells on the Bradley plantation, 5 miles north of Omaha, in Stewart County, tap water-bearing beds in this formation. (See p. 387.)

On account of the presence of lime, glauconite, and iron pyrites in many of the beds composing this formation, the contained waters are apt to be more highly mineralized than the waters obtained from the Lower Cretaceous deposits; but within the geographic limits mentioned the mineral content will generally be too small to render the waters unsuitable for domestic or for most industrial purposes.

Ripley formation.—The strata composing the Ripley formation are in part efficient and in part inefficient water bearers. The typical marine beds are, as a rule, either too compact to permit the free circulation of the waters, or, if sufficiently loose and porous, contain large percentages of lime and iron sulphide (pyrites or marcasite), which tend to render the waters hard and ferruginous and unsuitable for domestic and industrial purposes. That there are exceptions to this rule, however, has been proved by practical tests, for at Eufaula,

Barbour County, Ala., at Fort Gaines, Clay County, Ga., and near Fort Gaines in Henry County, Ala., the marine beds have yielded sufficient water of satisfactory quality for domestic and for some industrial uses.

The irregularly bedded shallow-water phases of the formation, which have been classified in part as the Cusseta sand member and in part as the Providence sand member, are favorable in both composition and texture to the storage of waters. Some waters derived from these beds are more or less ferruginous and sulphurous, but most of them are only moderately mineralized.

In Stewart, Marion, Schley, and Macon counties the Cusseta sand member dips southeast beneath the typical marine strata of the formation and passes to greater depths. For 15 or 20 miles or perhaps farther beyond the outcrop the buried representatives of the member may be regarded as a practicable source of water. The water-bearing beds of the Cusseta member would be reached along the southern border of the outcrop at depths of 100 to 300 feet, and at increasingly greater depths southward, until at 20 miles it would probably be necessary to drill 600 to 800 feet or more.

The Providence sand member of the formation is unconformably overlain by strata of Eocene age. Just how far to the southeast beneath the Eocene strata the member maintains its distinguishing shallow-water character is not known, but it probably does so for not less than 10 or 15 miles, within which distance it may be everywhere regarded as a probable source of good artesian waters. Within the suggested limits the beds should be reached at depths of 100 to 400 feet beneath the surface.

East of Macon County, in Houston and Twiggs counties, the Providence member directly overlies the Cusseta member and the two members together make up the entire thickness of the Ripley formation, probably 800 to 1,000 feet. As both of these members are water bearing and as the Lower Cretaceous deposits which directly underlie them are also water bearing, there should be little difficulty in obtaining ample supplies of excellent water in this region.

Little is known of the physical character of the southward extension of the Ripley formation beneath the overlying Eocene. That the terrane contains waters suitable for domestic and for many industrial purposes, at least as far south as Dougherty and Early counties, has been proved by practical tests. In wells at Albany, Dougherty County, water-bearing beds are tapped in the Ripley formation at depths of 660 to 710 feet, 840 to 900 feet, and 1,310 to 1,320 feet. In a well at Blakely, Early County, water-bearing beds were reached at 570 and 812 feet, the lower bed furnishing the municipal water supply.

WATER IN TERTIARY SYSTEM.

EOCENE SERIES.

Midway formation.—The Midway formation consists of 200 to 400 feet of sedimentary deposits, mainly of marine origin, including sands, clays, marls, and limestones. The lithologic character of the formation is favorable for the absorption and circulation of water, and as the strata dip continuously southward the terrane is an important aquifer.

The belt of outcrop of the Midway formation is 8 to 15 miles wide, extending from Clay County northeastward into Macon and Houston counties. The elevation of the greater part of this belt above sea level is 400 to 550 feet, with somewhat lower elevations along the larger streams. The strata composing the formation dip southward at the rate of 20 or 30 feet to the mile, but probably become flatter under cover of the younger formations. The thickness probably also diminishes. The formation is believed to be the source of the water of deep wells in Sumter, Lee, Terrell, Randolph, Dougherty, and Calhoun counties, in which, south of the belt of outcrop, the top of the formation should be reached at 100 to 500 feet. As certain of the formations which overlie the Midway contain large quantities of water, it is not everywhere necessary to drill to the Midway.

In the region east of Ocmulgee River no evidence of the presence of the formation has been found either in natural outcrops or in wells.

The following wells probably tap water-bearing beds in this formation: (1) At Shellman, Randolph County, a public well, depth 410 feet; (2) at Cuthbert, Randolph County, a well owned by the town, depth 1,000 feet (depth to principal water-bearing bed 340 to 400 feet), and a well owned by the Cuthbert Ice Co., depth 435 feet; (3) near Ducker station, Dougherty County, the Fort well, depth 547 feet; (4) at Montezuma, Macon County, numerous wells less than 160 feet deep.

The waters are generally suitable for domestic and for most industrial purposes.

Wilcox formation.—The Wilcox formation is relatively thin. It outcrops in a narrow belt extending from Chattahoochee River to Flint River, chiefly in Clay, Randolph, Webster, and Sumter counties. So far as known it is not an important aquifer, although it is composed in part of beds of sand which probably carry waters in greater or lesser quantities.

Claiborne group.—The Claiborne group has been subdivided into the McBean formation below and the Barnwell sand above. The McBean formation includes a lithologic phase which has been designated the Congaree clay member. (See pp. 73–80.) The available data are insufficient for discriminating these divisions in wells south

of the belt of outcrop, or where they are buried by later overlying formations, and most of the water-bearing beds are referred to the Claiborne group as a whole instead of to one of its subdivisions.

The Claiborne group outcrops in the northern part of the Coastal Plain of Georgia in an irregular belt 2 to 40 miles wide extending entirely across the State from Savannah River to Chattahoochee River. The widest part of the belt is between Savannah and Flint rivers, where the beds lap upon the Cretaceous deposits and in places extend entirely to and rest directly upon the crystalline rocks of the Piedmont Plateau. The Claiborne appears at the surface over much of Richmond, Burke, Glascock, Jefferson, Washington, Wilkinson, Twiggs, and Houston counties. Between Flint and Chattahoochee rivers the belt of outcrop is narrow and the Claiborne does not overlap and conceal the older formations.

The area of outcrop lies from 200 to 500 feet above sea level, from which elevation the strata of the Claiborne group dip southward beneath younger formations and probably extend to the coast. Little is known, however, concerning the thickness or character of the buried portion of the group.

The group is an important aquifer over the area in which it lies at or near the surface, the water-bearing beds being tapped by both shallow nonartesian wells and by deep artesian wells. The flowing wells at Louisville, Wadley, Bartow, Midville, and other places are located on the Claiborne and derive their waters from this group, chiefly from the McBean formation, at depths of 150 to 350 feet. The base of the McBean formation east of Ocmulgee River consists of 50 to 100 feet of clay or fuller's earth (Congaree clay member), which is relatively impervious and carries very little water, but which is overlain by coarse unconsolidated water-bearing sands. Southward it merges into alternating beds of sandy marl, limestone, and sand. The Claiborne consists in the main of irregularly bedded sands, clays, and marls, and, as individual beds of definite lithologic character are not persistent, the rainfall percolates readily through the strata, notwithstanding the local beds of impervious clay.

Flowing wells from this group may be expected along the lower lands bordering Oconee River in Laurens County, Ogeechee River in Jefferson, Burke, and Jenkins counties, and Briar Creek in Burke and Screven counties. At depths of not more than 500 feet the Claiborne should furnish large supplies in the northern parts of Laurens, Johnson, Emanuel, Jenkins, and Screven counties.

Deep wells at Wrightsville, Swainsboro, Millen, Millhaven, and elsewhere east of Ocmulgee River probably obtain their supplies from this group. West of Ocmulgee River few wells are known to obtain their waters from the Claiborne group.

The waters from the Claiborne group are generally suitable both for domestic and for most industrial purposes. None of those analyzed shows excessive total solids, the amount being generally less than 300 parts per million. The waters are hard, and some of them emit an unpleasant odor of hydrogen sulphide.

Jackson formation.—The Jackson formation consists mainly of limestone, more or less sandy, having a maximum thickness of 150 feet or less. It outcrops in a narrow belt chiefly in Sumter, Dooly, Houston, Twiggs, Wilkinson, and Laurens counties and is believed to underlie a large area to the south and southeast. Its more sandy portions and perhaps also some solution caverns in it contain artesian waters in large quantities and of suitable quality for domestic and for most industrial purposes.

OLIGOCENE SERIES.

Vicksburg formation.—The Vicksburg formation is an important aquifer. It consists mainly of porous limestones but also contains thin beds of clay and water-bearing sand. Throughout the area of outcrop the surface materials are residual argillaceous sands and sandy clays in which masses of flint are common and through which much water is admitted into the beds. The maximum thickness of the formation is believed to be about 300 feet. The area of outcrop ranges in elevation above sea level from about 125 to 450 feet.

The catchment area of the formation (see Pl. III, p. 52) is a belt 5 to 35 miles wide, embracing about 1,500 square miles, and extending from the Oconee River valley in Laurens County to Chattahoochee River in the southwestern part of the State. Its widest part is in the southwest. The beds dip gently to the southeast and south and under cover of the later formations extend to the Atlantic coast and to Florida.

The formation carries large quantities of water which throughout the area of outcrop can be obtained by drilling to depths of 100 to 400 feet. At a few places the formation will yield flows. In drilling underground streams and cavities are frequently tapped and afford large supplies of water. Water is also obtained from layers of sand interbedded with the limestones. East of Flint River, in the wire-grass region or Altamaha upland, the water-bearing beds of the formation are tapped by many deep wells. The depth to the formation in the region south and east of the outcrop varies from 50 or 100 feet in the northwest to perhaps 500 or 600 feet near the Atlantic coast. However, in wells the formation can not be easily differentiated from the underlying Jackson formation, nor from the overlying Chattahoochee formation, both of which are also water bearing.

The water has a low mineral content, is potable, and is used for general domestic purposes; the hardness is sufficient to render it somewhat objectionable in boilers and in laundries.

If the area west of Flint River were to become thickly populated, there might be some danger of pollution, for surface waters doubtless gain access to the underground supply through the numerous lime sinks.

Chattahoochee formation.—The Chattahoochee formation is composed mainly of soft porous limestone, but it also contains beds of calcareous clay and sandstone. The area of outcrop is relatively small, including a narrow belt east of Flint River in Decatur, Mitchell, Dougherty, Worth, and Crisp counties, isolated areas along the Florida line in Grady, Thomas, Brooks, Lowndes, and Echols counties, and small areas in the northeast in Screven, Jenkins, and Burke counties. The formation also probably outcrops along Ocmulgee River near Abbeville in Wilcox and Dodge counties. Although the area of outcrop is small, the formation is present throughout the greater part of south and southeast Georgia beneath the Alum Bluff formation. The thickness of the terrane is estimated to be 100 to 150 feet. The limestones are in part porous and cavernous and throughout much of the region carry large quantities of water. As the catchment area is small much of the water probably enters the formation through lime sinks, although a considerable part of it may find its way by percolation through the overlying Alum Bluff formation.

In the area outlined the formation lies at depths ranging from a few feet along its northwestern margin to estimated depths of 400 or 500 feet along the coast. Over the greater part of the region its depth does not exceed 350 feet. The waters of deep artesian wells at Waycross (?), Valdosta, Quitman, Boston, Thomasville, Adel, Lumber City, and Rockyford are believed to be obtained in whole or in part from this formation.

The waters of the Chattahoochee are hard, and in places emit a strong odor of hydrogen sulphide, but they are potable and are suitable for domestic and for most industrial purposes. Where lime sinks occur, as in Brooks, Lowndes, and Thomas counties, the danger of contamination from surface sources renders it desirable to sink wells to lower formations.

Alum Bluff formation.—The Alum Bluff formation consists of sandy clays, in places resembling fuller's earth, and subordinate amounts of sand, sandstone, and marl or limestone. On account of its predominantly argillaceous character the formation is not an important aquifer, although it contains local water-bearing beds.

The outcrops of the strata are confined roughly to the area east of Flint River and south of Cordele, Dublin, Tennille, Midville, and

Millen. In its distribution the formation corresponds approximately to the underlying Chattahoochee formation. The strata dip slightly southward. On the north their maximum elevation is 300 to 400 feet above sea level, and on the coast, in McIntosh, Glynn, and Camden counties, they lie 100 feet or more below sea level. Throughout the greater part of its extent it is overlain by the undifferentiated Oligocene to Pleistocene deposits.

In the area outlined, except in the coast counties, the formation lies at depths of not more than 100 or 150 feet, and at many places it is very near the surface. Although locally the formation furnishes large supplies of water its water content is in the main relatively small and at many places it is necessary to sink wells to the limestones of the underlying Chattahoochee, Vicksburg, or Jackson formations. In wells the deposits can not be sharply differentiated from the underlying Chattahoochee formation. Near the Florida line, in Decatur, Grady, Thomas, Brooks, and Lowndes counties, the larger streams have cut their valleys entirely through the deposits, exposing the underlying limestones of the Chattahoochee formation, thus permitting the freer escape of the contained waters and lessening the chance of obtaining artesian supplies. In the southeastern part of the Coastal Plain conditions are more favorable for the presence of artesian waters in the deposits, and it is probable that many of the flowing wells in McIntoch, Liberty, Glynn, and Camden counties derive their waters from this source.

The waters from these deposits are potable and are as suitable for domestic and industrial purposes as those of the underlying formations. Where large supplies happen to be found in them nothing will be gained by drilling deeper except where there is a probability of obtaining artesian flows.

MIOCENE SERIES.

Less definite information is at hand regarding the Miocene of Georgia than concerning any other geologic division of the Coastal Plain of the State. However, it is believed that 200 or 300 feet of sands, clays, and marls of Miocene age exist along the coast and that these deposits constitute a very important artesian reservoir. (See pp. 97–100.)

The Miocene deposits are almost entirely hidden by younger formations, the area of outcrop being insignificant. The deposits probably nowhere extend more than 50 or 60 miles back from the ocean front, and they probably nowhere reach an elevation of 100 feet above sea level. It is believed that some of the artesian wells less than 150 or 200 feet deep in Camden, Glynn, and McIntosh counties, and on the sea islands of Liberty, Bryan, and Chatham counties, obtain their supplies from Miocene strata.

The few available analyses of Miocene waters show moderately hard waters, most of which emit rather strong odors of hydrogen sulphide. The waters are used for both domestic and manufacturing purposes.

PLIOCENE? SERIES.

The Charlton formation (probably Pliocene), which outcrops along St. Marys River on the Florida side and adjacent to Charlton County, Ga., is believed to be relatively thin and of small geographic extent and is therefore considered unimportant as a source of water.

UNDIFFERENTIATED OLIGOCENE TO PLEISTOCENE, INCLUSIVE.

The surface material over the greater part of the region east of Flint River, in an area the northern limit of which is marked approximately by a line connecting Unadilla, Hawkinsville, Dublin, Tennille, Wadley, Waynesboro, and Girard, although small isolated areas probably occur north of these towns and west of Flint River, consists of irregularly bedded sands, clays, and gravels, and contains water-bearing beds. However, as the deposits are relatively thin and are broadly distributed as a nearly horizontal sheet the contained waters are under little or no hydrostatic pressure and belong mainly to the nonartesian class. The deposits are overlain by a thin covering of gray sand, which is in the main residual but is in part of Pleistocene terrace origin.

Most of the shallow wells in the area just outlined tap water-bearing beds, and numerous small springs issue at the contacts of local beds of clay and sand. The shallow wells yield sufficient quantities of water for farm and domestic use except in times of unusual drought; large, permanent supplies from these formations are not to be expected.

The waters of the deposits are generally soft and are low in their content of dissolved mineral matter, and are wholesome where properly protected from surface contamination. Some seepage springs have been noted, the waters of which are sufficiently ferruginous to render them disagreeable to the taste.

WATER IN QUATERNARY SYSTEM.

PLEISTOCENE SERIES.

The marine Pleistocene terrace deposits, which cover a large area bordering the Atlantic coast (Pl. III, p. 52), and the alluvial terrace deposits of Pleistocene age, which are present in small areas bordering the larger rivers of the Coastal Plain, contain nonartesian waters which are tapped by numerous shallow dug or driven wells. The water in these wells frequently stands within a foot or two of the surface. On account of the high content of organic matter in

many of the waters from shallow sources and their liability to pollution they are not considered as suitable as artesian waters for domestic uses.

The terrace deposits bordering the larger rivers are thin and do not yield large supplies. There are many shallow wells on the terraces along Chattahoochee River, but little detailed information has been obtained concerning them. Along Ocmulgee, Altamaha, Oconee, and Savannah rivers the lowest terrace plain is swampy and is sparsely populated, and for this reason few wells have been sunk. There are shallow wells in Pleistocene terrace deposits at Macon, Hawkinsville, Lumber City, Dublin, and Augusta, but the waters of these wells should not be used for domestic purposes on account of the danger of pollution.

COUNTY DESCRIPTIONS.

APPLING COUNTY.

GENERAL FEATURES.

Appling County is in the southeastern part of the Coastal Plain. Baxley, the county seat, is on the main line of the Southern Railway, 118 miles from Macon and 69 miles from Brunswick. The area of the county is 604 square miles and the population is 12,318 (census of 1910). Agriculture and the production of rough lumber and naval stores are the principal industries.

TOPOGRAPHY.

The county is nearly level to gently rolling; the southern part lies within the Satilla drainage basin, the principal streams being Little Satilla River and Hurricane Creek. The divide between the Altamaha and the Satilla drainage basins is a flat pine-woods country, which is traversed by the Southern Railway. Shallow cypress ponds from 100 to 200 feet in diameter and bays and upland swamps, many of them several hundred acres in extent, dot this plain. Big Pond, 7 miles north of Baxley, has an area of 7 or 8 square miles. In the north, near Altamaha River, which forms the northern boundary, the land is rolling. In the west numerous creeks and branches flow sluggishly through shallow valleys.

The known elevations above sea level along the Southern Railway are; Graham, 240; Pinegrove, 229; Baxley, 206; Wheaton, 201; Surrency, 187. The elevation of the swamp along Altamaha River, as estimated from elevations established on the river by the United States Corps of Engineers, is hardly more than 75 or 80 feet above sea level, and the elevation of the swamp of Little Satilla River, in the extreme southeast corner of the county, is about the same.

GEOLOGY.

Except for Pleistocene terrace deposits of sand and clay, laid down in narrow areas bordering Altamaha River, the surface materials throughout the greater part of the county consist of undifferentiated deposits of Oligocene and later age, comprising irregularly bedded sands and sandy clays, and interbedded layers of argillaceous sandstone and quartzite. These surficial deposits are the source of the waters obtained in shallow wells. Beneath them throughout the entire county is the Alum Bluff formation, which consists of 100 feet or more of soft sandy clays and sands with interbedded thin layers of soft sandstone and quartzite, and which outcrops in the bluffs of Altamaha River.

The Alum Bluff formation is underlain by 400 feet or more of water-bearing limestones, which probably represent in descending order the Chattahoochee, Vicksburg, and Jackson formations, and which contain important water-bearing beds. Beneath the limestones, in descending order, is a series of sands, clays, and marls of Eocene and Cretaceous age, probably aggregating several thousand feet in thickness, which at an undetermined depth rest upon a basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The shallow wells of the county, both dug and driven, range in depth from 10 to 50 feet. These wells draw from the undifferentiated surficial deposits and afford abundant supplies of soft but not always wholesome water. The land is low and poorly drained, and in rainy periods the water stands very near the surface and has an unpleasant taste due to iron or to organic matter. Small seepage springs occur throughout the county.

Information in regard to deep-seated water is very scanty. However, the prospects may be considered good for obtaining abundant supplies of potable water at depths of 150 to 1,000 feet or more. The Alum Bluff formation probably contains water-bearing sands at depths of 150 to 250 feet or more, and the upper part of porous water-bearing limestones referred to the Chattahoochee, Vicksburg, and Jackson formations should be reached at depths of 350 or 400 feet. Flowing wells probably can not be obtained in the county, except, possibly, on a small area of lowland bordering Altamaha River.

LOCAL SUPPLIES.

Baxley (population 831, census of 1910).—The town of Baxley owns an artesian well which supplies the greater part of the population with water for domestic use. The well, which was drilled in

1895, was originally 461 feet deep, but has since become partly filled with sand, and is now only 204 feet deep. The water, which is probably derived from Alum Bluff strata at a depth of about 200 feet, rises to within about 80 feet of the surface, and is clear, potable, and soft, differing in the latter respect from most of the deep-well waters of this part of the Coastal Plain. The water is notable for its high content of silica and for the appreciable amount of phosphorus which it contains, but is suitable for domestic purposes, so far as can be determined from a mineral analysis. The following analysis of a sample of the water was made by Edgar Everhart:[1]

Analysis of water from 204-foot town well at Baxley.

	Parts per million.
Silica (SiO_2)	97
Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$)	17
Calcium (Ca)	3.9
Magnesium (Mg)	.7
Sodium (Na)	13
Potassium (K)	4.4
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	27
Sulphate radicle (SO_4)	1.6
Chlorine (Cl)	12
Phosphate radicle (PO_4)	5.4
Total dissolved solids	169
Free carbon dioxide (CO_2)	31

New Lacey.—An oil-prospecting well, reported to be 440 feet deep, has been drilled on the John Aldredge farm, a mile southeast of New Lacey. Water rises to within 50 feet of the surface.

BAKER COUNTY.

GENERAL FEATURES.

Baker County is in the southwestern part of the Coastal Plain between Flint and Chattahoochee rivers. Its area is 357 square miles and its population 7,973 (census of 1910). The county contains no large towns or manufacturing establishments. Agriculture, lumbering, and the production of turpentine and resin are the chief industries.

TOPOGRAPHY.

The county is mainly a nearly level plain. Although but few determinations of altitude have been made the surface is known to range in elevation above sea level from about 125 or 150 feet in the southeast to about 200 feet in the north. Lime sinks, small, shallow cypress ponds occupying lime sinks, small, open lakes or ponds, and broad creek swamps characterize the topography. The drainage of

[1] Georgia Geol. Survey Bull. 15, p. 51, 1908.

the county is chiefly by subterranean streams through lime sinks, small surface streams being rare. Flint River forms the eastern boundary of the county. Two Pleistocene terraces—an alluvial plain about 15 feet above the river and a higher sand-covered terrace 40 to 50 feet above the same datum—border the river. The tributaries of Flint River, Ichawaynochaway, Chickasawhatchee, and Coolewahee creeks, which flow southward through the county, have very shallow valleys and very low banks and in places spread out so widely in swamps that it is difficult to recognize their main channels.

GEOLOGY.

The county is directly underlain by the Vicksburg formation which is estimated to be not less than 300 feet thick. This formation is represented at the surface by residual sands and clays and by flint fragments. Beneath the residual materials the formation probably consists mainly of limestones interbedded, according to well records, with sands. A thin deposit of loose residual sand covers the upland, and Pleistocene deposits, which have very little bearing on the water supply, occur along Flint River and Ichawaynochaway Creek.

The Vicksburg formation is underlain by several hundred feet of undifferentiated limestones, sands, clays, and marls of Eocene age, which contain water-bearing beds. The Eocene deposits are underlain by 2,000 feet or more of sands, clays, and marls of Cretaceous age, beneath which at an undetermined depth is the basement of ancient crystalline rocks. The Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The shallow open wells of the county vary in depth from 30 to 40 feet. The water of many of them is hard and is considered unwholesome. The water is derived from the Vicksburg formation and from the residual sands and clays resulting from the weathering of this formation. There are several perennial limestone springs in the county, but their waters are used only locally for drinking and cooking. The largest are Blue Spring, at the mouth of Coolewahee Creek at Newton, and Lester Spring, 8 miles northeast of Newton.

Two deep flowing wells have been obtained in the county, and it is probable that others can be obtained anywhere east of Ichawaynochaway Creek. Limestones of the Vicksburg formation will yield large supplies of water at depths of 300 feet or less, and the water-bearing strata of the Eocene and Cretaceous deposits which underlie the Vicksburg and which furnish flows in Calhoun and Dougherty counties will yield waters at depths of 300 to 1,500 feet or more.

LOCAL SUPPLIES.

Newton (population 364, census of 1910).—An artesian well owned by Newton is 825 feet deep and flows at the rate of 15 gallons per minute; the water will rise 35 feet above the surface. McCallie[1] has published the following log, giving I. B. Perry as authority:

Log of town well at Newton.

	Thickness.	Depth.
	Feet.	*Feet.*
Sands and clays	80	80
Rock	300	380
Quicksand and rock	200	580
Marl, sand, and rock	100	680
Marl	120	800
Rock, white, honeycombed, water bearing	25	825

The water-bearing strata are probably in the lower part of the Eocene. The following analysis of the water was made by Edgar Everhart:[1]

Analysis of water from an 825-foot town well at Newton.

	Parts per million.
Silica (SiO_2)	20
Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$)	3.6
Calcium (Ca)	4.5
Magnesium (Mg)	3.2
Sodium (Na)	59
Potassium (K)	1.9
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	162
Sulphate radicle (SO_4)	9.3
Chlorine (Cl)	7.0
Total dissolved solids	190
Total hardness	27
Permanent hardness	23
Free carbon dioxide (CO_2)	74

Elmodel.—Elmodel is a small village 12 miles west of Newton. According to M. A. Jarrard, driller, an artesian well at this place, completed in 1907, is 661 feet deep, and is cased to a depth of 365 feet. The diameter at the top is 4¼ inches and at the bottom 2 inches. When finished, the water rose in a pipe 30 feet above the surface and flowed 70 gallons a minute. A slight decrease in the yield is thought to be due to a leak in the casing. The water is used for general domestic purposes.

[1] Georgia Geol. Survey Bull. 15, p. 52, 1908.

Log of well at Elmodel.

	Thickness.	Depth.
	Feet.	*Feet.*
Sand and clay	160	160
Rock with thin layers of clay	100	260
Sand	100	360
Rock, very hard	10	370
Marl, blue	290	660
Stopped on white, porous, water-bearing rock.		

The water probably comes from the Midway or the Wilcox formation of the Eocene.

Mimmsville.—Drilled wells 200 feet deep have been reported from near Mimmsville, in the southwestern part of the county.

BALDWIN COUNTY.

GENERAL FEATURES.

Baldwin County is near the central part of Georgia, on the border between the Piedmont Plateau and the Atlantic Coastal Plain. Its area is 307 square miles and its population 18,354 (census of 1910). Agriculture and the mining and manufacture of clay products are the chief industries.

TOPOGRAPHY.

Approximately the southern half of the county is included within the Atlantic Coastal Plain and forms part of the physiographic division known as the fall-line hills. This part of the county is drained by Oconee River, the two principal tributaries of which are Town Creek and Fishing Creek. The surface has been much dissected by these streams and their tributaries and is therefore hilly, the maximum topographic relief being probably between 350 and 400 feet. Two narrow, fairly well defined Pleistocene terrace plains have been formed along Oconee River, one lying 10 to 20 feet and the other 40 to 50 feet above low-water level. The general hilly character of the area has been thus modified in a tract a mile or more in width bordering the river.

GEOLOGY.

Crystalline rocks of the Piedmont Plateau region or their decomposed products outcrop at the surface over more than half of the county and are present beneath Cretaceous and younger deposits in the remainder. Coarse, unevenly bedded sands and clays of Lower Cretaceous age form the surface materials over the greater part of the area between Oconee River and the eastern boundary of the county. They rest upon the crystalline rocks, which appear in the bed of Oconee River on the west and of Gum Creek on the east. Strata of the same age and of similar character rest upon the crystal-

line rocks in the southwestern part of the area south of Milledgeville. The maximum thickness of the Lower Cretaceous deposits within the county is probably not greater than 100 or 150 feet.

In a small area in the vicinity of Stevens Pottery the Lower Cretaceous sediments are unconformably overlain by relatively thin, overlapping sands and clays belonging to the Claiborne group of the Eocene. Some terrace loams, sands, and gravels of Pleistocene age have been deposited along Oconee River. (See Pl. III, p. 52.)

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The water supplies for domestic use in the Coastal Plain areas in Baldwin County are derived chiefly from wells of the dug type 20 to 80 feet in depth and from small springs. The waters yielded by both wells and springs come principally from the beds of sand which predominantly compose the Lower Cretaceous deposits. The waters are of satisfactory quality except where locally contaminated from surface sources.

Small creeks and branches furnish an abundant supply of excellent water for the use of domestic animals and for local steam-producing plants.

As the Lower Cretaceous strata probably do not exceed a thickness of 100 or 150 feet within the county limits, and as only slight artesian pressure is developed, wells drawing water from this source can scarcely be classed as artesian. However, moderate amounts of water of good quality can be obtained from the porous beds of sand which largely compose the deposits.

LOCAL SUPPLIES.

Milledgeville (population 4,385, census of 1910).—Milledgeville, the county seat, is situated near the fall line, which marks the boundary between the Coastal Plain and the Piedmont Plateau.

The town is equipped with a water-supply system concerning which the following data have been furnished by Mayor M. S. Bell:

The water plant is owned by the Baldwin County Water Co., of Philadelphia, Pa., and draws from Fishing Creek, 1½ miles northwest of the center of the town. Two pumps, having a combined daily capacity of 750,000 gallons, force the water from its source to a standpipe which has a capacity of 150,000 gallons, and affords a pressure of 75 pounds. The distributing mains have a total length of 5½ miles. There are 278 domestic taps and 82 fire hydrants. The total daily consumption for all purposes is 250,000 gallons. The water is soft. The State farm is located within the basin of Fishing Creek and the creek receives the drainage from the farm a short distance above the waterworks intake.

Stevens Pottery.—So far as reported the only attempt yet made to drill a deep artesian well in the county was made in 1893 at the Stevens Pottery. W. C. Stevens states that at a depth between 60 and 75 feet a strong flow of water was encountered but was cased off, and drilling was continued through soft "granite" rock to a depth of 150 feet. The well has been abandoned. The soft rock was probably the upper decayed portion of the crystalline basement rocks which underlie the Lower Cretaceous deposits.

BEN HILL COUNTY.

GENERAL FEATURES.

Ben Hill County is in the central part of the Coastal Plain of Georgia, in the wire-grass section. Its population (census of 1910) is 11,863 and its area is 256 square miles. Fitzgerald, the only large town in the county, is the county seat.

TOPOGRAPHY.

The county is gently rolling and the relief is slight; the elevations probably ranging from 325 to 400 feet above sea level. The elevation at Fitzgerald, at the Atlanta, Birmingham & Atlantic Railroad station, is about 385 feet. Ocmulgee River forms a part of the northern boundary of the county and is the only stream of noteworthy size.

GEOLOGY.

The greater part of the county is underlain by 100 feet or less of irregularly bedded sands and clays which weather to gray or yellow sands several feet thick. These deposits are underlain by the Alum Bluff formation, which consists of 100 feet or more of greenish-gray sands and clays and which appears in the bluff of Ocmulgee River at the mouth of House Creek, in the northeastern part of the county. The Alum Bluff is probably underlain, in descending order, by the Chattahoochee and Vicksburg formations (Oligocene) and the Jackson formation (Eocene), which consist mainly of water-bearing limestones and the combined thickness of which is probably between 300 and 500 feet. The Jackson formation is underlain by undifferentiated sands, clays, and marls of Eocene age, and these are underlain by undifferentiated Cretaceous deposits which at an unknown depth rest upon a basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Water for domestic purposes is obtained chiefly from dug wells of shallow depth. The waters of streams and ponds are used locally for steam-producing purposes. Springs are comparatively few and are

of little importance. The only deep wells reported are at Fitzgerald and Bowens Mill.

Throughout the county wells drilled to depths of 200 to 1,500 feet or more may be expected to furnish abundant supplies of water, but the prospects for obtaining flows are very poor, except on a narrow area of lowland bordering Ocmulgee River, and in the valleys of some of the small tributaries entering the river.

LOCAL SUPPLIES.

Fitzgerald (population 5,795, census of 1910).—The town of Fitzgerald owns a water-supply system and obtains water from an artesian well, using 40,000 gallons a day. The water is satisfactory for general domestic purposes but is not used for manufacturing. The city well (No. 2, Table 1) is 825 feet deep and the water which probably comes from Eocene strata is reported to rise to within 100 feet of the surface. The following is an analysis of the water by Edgar Everhart:[1]

Analysis of water from an 825-foot town well at Fitzgerald.

	Parts per million.
Silica (SiO_2)	13
Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$)	10
Calcium (Ca)	20
Magnesium (Mg)	5.2
Sodium (Na)	8.2
Potassium (K)	1.9
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	72
Sulphate radicle (SO_4)	3.7
Phosphate radicle (PO_4)	Trace.
Chlorine (Cl)	20
Total dissolved solids	118
Free carbon dioxide (CO_2)	28

There are several wells at Fitzgerald which are reported to be about 650 feet deep, and one which is 381 feet deep (No. 3, Table 1). The water-bearing beds tapped by these wells are believed to be in the undifferentiated Oligocene and Eocene limestones described on page 140. McCallie[2] has published the following log of the 381-foot well:

Log of 381-foot well of Fitzgerald Ice Co., at Fitzgerald.

	Thickness.	Depth.
	Feet.	*Feet.*
Red clay and sand	100	100
Quicksand?	125	225
Limestone with some clay	156	381

[1] Georgia Geol. Survey Bull. 15, p. 123, 1908. [2] Idem, p. 122.

Bowens Mill (population 79, census of 1910).—Bowens Mill is a small community in the northeastern part of the county, near Ocmulgee River. A well (No. 1, Table 1) owned by R. V. Bowens is 670 feet deep and is said to flow at the rate of 50 gallons per minute at a height of 15 feet above the surface. The water is reported to be hard and sulphurous.

TABLE 1.—*Wells in Ben Hill County.*

No.	Location.	Owner.	Authority.	Approximate elevation above sea level.	Depth.	Diameter.	Depth to principal water-bearing bed.	Level of water above or below surface.	Yield per minute.	
									Flow.	Pump.
				Feet.	*Feet.*	*In.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*
1	Bowens Mill (near Fitzgerald).	R. V. Bowens, Fitzgerald.	T. H. Beale	.....	670	.....	.....	+ 15	50	.....
2	Fitzgerald	City	S. W. McCallie [a]	388	825	8	370–500	−100	.....	100
3	.....do.....	Fitzgerald Ice Co.	.....do.....	388	381	.....	.....	.....	.....	.....

No.	Quality.	Use.	Principal water bed.		Remarks.
			Geologic horizon.	Character.	
1	Sulphurous	Domestic	Eocene	.....	
2	Analysis, p. 141	Municipal supply	.....do.....	Porous limestone.	Several other wells at Fitzgerald are reported to be about 650 feet deep. See log, p. 141.
3	.....	Manufacture of ice.	Vicksburg formation?	.....	

[a] Georgia Geol. Survey Bull. 15, pp. 122, 123, 1908.

BERRIEN COUNTY.

GENERAL FEATURES.

Berrien County lies in the south-central part of the Coastal Plain of Georgia, between Alapaha River on the east and Little River on the west. Its area is 735 square miles and its population is 22,772 (census of 1910). Agriculture and the production of lumber and naval stores are the chief industries. The main industrial use to which the waters are put is the production of steam in the boilers of sawmills and cotton gins.

TOPOGRAPHY.

The county is nearly level. The principal streams, Alapaha, Little, and Withlacoochee rivers, and their numerous small tributaries, flow sluggishly through swamps without definite channels and have accomplished little erosion. The valleys are shallow, the maximum relief being about 70 feet. Cypress ponds or swamps are com-

mon on the flat lands in the southern part of the county. The known railroad elevations are Adel, 246; Alapaha, 293; Cecil, 250; Enigma, 309; Lenox, 300; and Sparks, 241.

GEOLOGY.

The surface formation consists of 50 or 60 feet of sands and clays, probably Oligocene, and is the source of the water of seepage springs and shallow wells. The Alum Bluff formation, which consists of clays and sands having a probable maximum thickness of 200 feet, outcrops in the valleys of Alapaha, Withlacoochee, and Little rivers. The formation contains local water-bearing beds, as at Milltown, but in general it is believed to be of little importance as an aquifer.

Thin coverings of Pleistocene sand and clay, deposited on the narrow terraces bordering the rivers, yield waters locally and are the source of a few springs, but are of relatively slight importance as aquifers.

Limestones of the Chattahoochee formation underlie the Alum Bluff formation at probable depths of 250 or 275 feet, and are in turn underlain in descending order by the Vicksburg and Jackson formations, which consist chiefly of limestones. These formations are water bearing and will yield abundant supplies.

The Jackson formation is underlain in descending order by undifferentiated strata of Eocene and Cretaceous age, probably having an aggregate thickness of 2,000 feet or more, which at an undetermined depth rest upon ancient crystalline rocks. The Eocene and Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Shallow open and driven wells, ranging in depth from 10 to 65 feet and yielding soft water, are the principal sources of domestic supply in the small villages and rural districts. On the flat lowlands the water table is only a few feet beneath the surface and during rainy weather is frequently so near the surface that water can be dipped from the wells by hand. Driven and bored wells are practicable over the whole county, and should be used in preference to open dug wells, which are more likely to be contaminated by surface drainage.

In places at or near the edges of swamps or poorly drained depressions there are small seepage springs, some of which yield unwholesome waters. The waters of the ponds, creeks, and rivers are dark or black from decayed vegetation.

Artesian water can doubtless be obtained anywhere in the county at depths of 100 to 1,500 feet or more, but the chance for obtaining natural flows is slight. Artesian wells have been drilled at Adel, Sparks, Nashville, Milltown, and Heartsease.

LOCAL SUPPLIES.

Adel (population 1,902, census of 1910).—The town of Adel owns an artesian well and has a public water-supply system, but a large part of the population uses shallow open wells. The public artesian well (No. 2, Table 2), drilled in 1907, is 675 feet deep and 10 inches in diameter. The water rises to within 50 feet of the surface and the yield is 500 gallons per minute. The water is hard (see analysis 1, Table 3) and the content of total solids is high, rendering it less suitable for general domestic purposes than most of the artesian waters of the Coastal Plain of Georgia. The well probably penetrates the upper part of the Eocene. S. W. McCallie[1] gives the following account of another artesian well (No. 1, Table 2) at this place:

The Adel well, completed in 1893, is 4½ inches in diameter and 280 feet deep. The water rises to within 154 feet of the surface. Mr. J. B. Spencer furnishes the following [partial] record:

Log of 280-foot well at Adel.

	Feet.
Sandy soil	2
Red clay	10
White sand	10
Blue clay with sandstone bowlders	125
Fine white sand	25
Limestone with thin layers of flint (water bearing at 229 feet)	100

Sparks (population 842, census of 1910).—The town of Sparks owns an artesian well 407 feet deep (No. 6, Table 2) which supplies the greater part of the population with water for all purposes. The analysis (No. 2, Table 3) shows a moderately hard carbonate water, calcium and magnesium being the principal bases.

Nashville (population 990, census of 1910).—Nashville owns a public water-supply system which obtains water from an artesian well (No. 5, Table 2) completed in 1907. The water is reported to be hard, but is satisfactory in other respects, and is used for general domestic purposes and for the manufacture of ice. The well is 436 feet deep and 6 inches in diameter. The water rises to within 125 feet of the surface, but is lowered 25 feet, or to 150 feet below the surface, by pumping 135 gallons a minute. The shallow wells in the town are from 20 to 40 feet in depth and afford soft waters.

Milltown (population 1,247, census of 1910).—Open wells, 10 to 30 feet in depth, are the principal source of water supply at Milltown. There is one deep well in the town (No. 4, Table 2), information concerning which has been furnished by McCallie[2] as follows:

The G. V. Gress Lumber Co.'s well, located at Milltown, was completed October 25, 1903. The well is 6 inches in diameter and 260 feet deep, and it furnishes a good supply of sulphureted water, rising to within 80 feet of the surface. The main water supply is said to come from sand 100 feet from the surface. The water is used for drinking and other purposes.

[1] Georgia Geol. Survey Bull. 15, p. 53, 1908. [2] Idem, p. 55.

Heartsease.—A deep well at Heartsease (No. 3, Table 2), owned by the Gun Manufacturing Co., is reported to be 800 feet deep. The water rises to within 300 feet of the surface.

TABLE 2.—*Wells in Berrien County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Adel			J. B. Spencer[a]	1893	246
2	do	Town	White & Co.		1907	246
3	Heartsease	Gun Manufacturing Co.		Postmaster		
4	Milltown	G. V. Gress Lumber Co.		S. W. McCallie[b]	1903	
5	Nashville	Town		J. W. Sirmans, mayor.	1907	
6	Sparks, 100 yards northeast of post office.	do		Mark McCaine and E. R. Slade.	1908	

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	280	4½	229		154				
2	675	10			50		500	Steam pump.	Hard and sulphurous. Analysis 1, Table 3.
3	800				300		20	Air-lift pump.	Hard.
4	260	6	100		80				Sulphurous.
5	436	6	400		125		135	Air-lift pump.	Hard.
6	407	10			45		300	do	Hard. Analysis 2, Table 3.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Chattahoochee formation?	Limestone	See log, p. 144.
2	Municipal supply.	Eocene		10-inch casing to 60 feet. Cost of well, $2,000.
3		do		
4	Manufacturing	Alum Bluff formation.	Sand	
5	Municipal supply.	Vicksburg formation?	Soft rock	6-inch casing to 300 feet. Cost of well, $1,200; of machinery, $1,200.
6	do	do	Sand	10-inch casing to 407 feet. Cost of well, $1,000.

[a] Georgia Geol. Survey Bull. 15, p. 53, 1908.

[b] Idem, p. 55, 56.

TABLE 3.—*Analyses of well waters from Berrien County.*

[Parts per million.]

	1	2
Silica (SiO_2)	47	31
Iron (Fe)	4.0	.3
Calcium (Ca)	150	50
Magnesium (Mg)	72	16
Sodium (Na)	22	4.3
Potassium (K)		.6
Carbonate radicle (CO_3)	.0	
Bicarbonate radicle (HCO_3)	168	136
Sulphate radicle (SO_4)	518	72
Nitrate radicle (NO_3)	.0	
Chlorine (Cl)	21	5.0
Total dissolved solids	972	252

1. Well No. 2, Table 2. Sample collected June 13, 1911; Edgar Everhart, analyst.
2. Well No. 6, Table 2. Edgar Everhart, analyst.

BIBB COUNTY.

GENERAL FEATURES.

Bibb County is in the central part of the State on the border between the Piedmont Plateau and the Atlantic Coastal Plain. Its area is 277 square miles and its population (according to the census of 1910) is 56,646. In the city of Macon the chief industries are the extraction of cottonseed oil and the manufacture of cotton goods, wagons, agricultural implements, fertilizers, lumber products, and food preparations. Outside of Macon agriculture is the chief industry.

TOPOGRAPHY.

The portion of the county included within the Coastal Plain is a part of the physiographic division known as the fall-line hills. The tops of the higher hills mark the position of a once-existing upland plain which has been largely destroyed by the erosion of Ocmulgee River and its several tributaries.

Detailed information concerning the topography is lacking, but the maximum relief is probably between 300 and 400 feet. The surface, which over much of the area is hilly, has been modified in an area several miles wide bordering Ocmulgee River by processes which have produced two fairly well defined Pleistocene terrace plains, one lying 10 to 20 feet and the other 60 to 75 feet above low-water level of the river.

GEOLOGY.

Crystalline rocks, more or less decomposed, probably of pre-Cambrian age, outcrop in the Piedmont Plateau. Their upper surface inclines southward and passes beneath the deposits of the Coastal Plain which form the surface materials over approximately two-thirds of the county. In the Coastal Plain area Lower Cretaceous deposits, consisting of several hundred feet of coarse, irregularly bedded, arkosic sands with clay lenses, rest immediately

upon the crystalline basement rocks. These deposits are unconformably overlain in a limited area in the southern part of the county by the Cusseta sand member of the Ripley formation, which consists of sands and clays similar in character to those constituting the Lower Cretaceous deposits. A thin overlap of strata belonging to the Claiborne group of the Eocene extends from Twiggs County into the eastern part of Bibb County and covers the Lower Cretaceous deposits in a limited area. (See Pl. III, p. 52.)

In narrow areas bordering Ocmulgee River Pleistocene terracing has taken place, and terrace deposits of loams, sands, and gravels 20 to 30 feet thick have been deposited upon the Cretaceous beds. Thin surficial deposits of gravel, which are present in discontinuous patches on the tops and upper slopes of some of the hills southwest of Macon, are tentatively referred to the Claiborne group of the Eocene.

The beds of sand which predominantly compose the formations of the Coastal Plain in this county contain waters of excellent quality in great abundance.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The chief sources of domestic water supply in Bibb County outside the city of Macon are dug wells 20 to 100 feet or more in depth and springs. On the first terrace lands bordering Ocmulgee River wells of shallow depth prevail, and they tap water-bearing beds at the base of the Pleistocene terrace deposits. Waters from these sources are of satisfactory quality unless contaminated by drainage from dwellings and stables. In the hilly areas away from the river it is necessary to sink the wells to 100 feet or more, except in the bottoms of the small valleys between the hills, where the water table stands nearer the surface. Except in a small area in the southern part of the county, where the Cusseta sand member is drawn upon, the water-bearing beds tapped by dug wells in the hilly areas are in the Lower Cretaceous deposits.

Springs are numerous throughout the Coastal Plain portion of the county. Many are small but some yield large quantities of water. The spring waters are commonly soft and of good quality, but are locally charged with moderate amounts of mineral matter. Two springs of commercial importance are White Elk or St. Winifreds Spring (see pp. 149–150), 7 miles east of Macon on the Edwards estate, and White Oak Spring near Macon, the waters of both of which are sold for drinking purposes.

Numerous small creeks and branches afford an abundant supply of water for stock and for steam producing.

The Lower Cretaceous sediments, which constitute the bulk of the deposits of the Coastal Plain part of the county, contain numerous beds of coarse unconsolidated sand and gravel capable of carrying large quantities of water. Except along their northern border, where they feather out against the crystalline rocks, these deposits may be regarded as a most promising source of artesian supplies. Southward from the border the deposits gradually thicken until in the extreme southern part of the county the base of the water-bearing strata lies at an estimated depth of 600 feet.

LOCAL SUPPLIES.

Macon (population 40,665, census of 1910).—The city of Macon is provided with a water-supply system, information concerning which has been furnished by H. S. Edwards, postmaster, and H. T. Lowell.

The plant is owned by the Macon Gas, Light & Water Co. and the source of supply is Ocmulgee River. The pumps which lift the water to the standpipe have a daily capacity of 10,000,000 gallons. The capacity of the standpipe is 3,000,000 gallons. The standpipe pressure is 50 pounds and the possible direct pressure from the pumps is 120 pounds. The length of the distributing mains is 42.7 miles. The number of domestic taps is 3,859; manufacturing taps, 68; and fire hydrants, 268. The total amount of water used daily for domestic purposes, manufacturing, street sprinkling, and sewer flushing is approximately 4,500,000 gallons. The water is filtered, after which it is satisfactory for all purposes.

Mr. Edwards has also furnished the following information concerning the private wells formerly used in Macon and concerning certain wells now in use in the vicinity of Macon:

> There are at present no wells in the city proper. Speaking generally and from memory, the wells formerly used in the residential portion among the hills were from 70 to 110 feet in depth. * * * Several of them were highly mineralized, iron predominating. On the lower levels the wells were from 20 to 40 feet deep, the waters rising 10 to 12 feet in them.
>
> South of the city, in the river valley, factories, railway shops, and ice works obtain a large supply of water from shallow wells. The supply from this source seems inexhaustible and the water is good. I understand, however, that it is destructive of boiler flues and is unfit for bleaching purposes in our cotton mills.

An unsuccessful attempt was made in 1890 by the Acme Brewing Co., of Macon, to obtain water from a deep artesian source. (See well No. 1, Table 4.)

Walden.—Several artesian wells (Nos. 3, 4, 5, 6, Table 4) which tap water-bearing beds in the Lower Cretaceous deposits have been drilled in the vicinity of Walden. The analysis of a sample of water from a 265-foot well owned by J. B. Willis (No. 3, Table 4) is given in Table 5 (analysis 3). The following is a log of a well (No. 7, Table 4) dug near Walden. The owner is authority for the lithology:

Log of well of W. G. Middlebrooks, 1½ miles west of Walden (No. 7, Table 4).

	Thickness.	Depth.
Upper Cretaceous, Ripley formation, Cusseta sand member:	*Feet.*	*Feet.*
Clay, red	22	22
Sand, white, and kaolin, about	48	70
Clay and sand, water bearing	12	82

Seven miles south of Macon.—A well (No. 2, Table 4) which taps a water-bearing bed in the Lower Cretaceous deposits was drilled in 1911 on the property of M. G. Thames, 7 miles south of Macon. W. J. Floyd, the driller, furnishes the following log:

Log of well of M. G. Thames, 7 miles south of Macon (No. 2, Table 4).

	Thickness.	Depth.
[Eocene? (Claiborne group):]	*Feet.*	*Feet.*
Sandy soil	1	1
Red clay	19	20
Very hard red clay	6	26
Reddish sand	8	34
[Lower Cretaceous:		
Whitish clay and "chalk" [white clay]	40	74
Pebbly sand	11	85
Sand and clay	25	110
Sand	15	125
Clay and "chalk" [white clay]	15	140
Sand	18	158
Layers of soft rock and sand pockets	12	170
Soft rock	25	195
Coarse gravel	4	199
Very hard clay and "chalk" [white clay]	11	210
White clay	40	250
Thin layers of rock with interbedded soft pockets, water bearing	20	270
Coarse gravel, stopped on hard rock	7	277

White Elk Spring.—White Elk or St. Winifreds Spring is on the Edwards estate, in the valley of Swift Creek, 7 miles east of the post-office building at Macon. The spring is at present owned by Mary R. Edwards and is being exploited by the White Elk Spring Co., of Macon. H. S. Edwards furnishes the following particulars:

The spring is one of three emerging from fine sand beneath a bed of white clay in close proximity. Glazed tile pipes, driven a short distance into the water-bearing sand, conduct the water into a brick and cement basin built over the mouth of the spring. The basin is covered with plate glass and illuminated by electric light. From the basin a galvanized pipe carries a portion of the water to a near-by bottling house, the remainder being discharged through another pipe into the valley below. The daily yield of the spring is 28,000 gallons, there being no appreciable variation in the rate of yield. The water is very clear and soft and is bottled and sold for drinking purposes, the principal market being the city of Macon. (See analyses 1 and 2, Table 5.)

The source of White Elk Spring is in the Lower Cretaceous sands, which here form the northwestern margin of the deposits of the Coastal Plain area. Crystalline basement rocks are said to outcrop a mile to the east.

Tufts Springs.—Tufts Springs, south of Macon at the edge of the Ocmulgee River swamp, were formerly the source of the water supply of the city of Macon.

TABLE 4.—*Wells in Bibb County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Macon	Acme Brewing Co., Macon, Ga.		S. W. McCallie[a]	1890	333±
2	Macon, 7 miles south of.	M. G. Thames	W. J. Floyd	W. J. Floyd	1911	[b] 450?
3	Walden, near	J. B. Willis		Owner (see also S. W. McCallie).[a]	1898	400?
4	do	B. F. Vinson		S. W. McCallie[a]		400?
5	Walden, one-half mile west of.	W. J. Willis	H. R. Teal, Richwood, Ga.	Owner (see also McCallie).[a]	1898	
6	Walden, 3 miles northwest of.	J. A. Whiteside	do	do	1900	
7	Walden, 1½ miles west of.	W. G. Middlebrooks.		Owner	1904	

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	955				None.				
2	277	4.5	249-270	195	104		20+	Deep-well cylinder and gasoline engine.	
3	265	4	250	75	70			Gasoline engine and windmill.	Soft. Analysis 3, Table 5.
4	185	4	180?	75	80				
5	185	4	185	75-100	60	Abundant.		Windmill	Soft.
6	190	3	185?		90		5	do	Do.
7	82		70			Abundant.		do	

[a] Georgia Geol. Survey Bull. 15, pp. 56-57, 1908.

[b] On a hill.

TABLE 4.—*Wells in Bibb County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Abandoned			Penetrated Lower Cretaceous strata for perhaps 100 feet and basement crystalline rocks to bottom. Well a failure and abandoned.
2	Domestic	Lower Cretaceous.	Coarse gravel	Bored; 4½-inch galvanized casing to 203 feet. See log, p. 149.
3	Drinking	do	Sand	Drilled; 250 feet of 4-inch casing. Cost of well, $300.
4		do	do	Drilled.
5	Domestic	do	Coarse gravel	Drilled; 110 feet 4-inch casing. Hard, flinty rock 120 to 140 feet. Pumped 6 hours with engine without lowering. Cost of well and windmill, $800.
6	do	do		Drilled. Cost of well and windmill, $600.
7	do	Cusseta sand member of Ripley formation.	Sand	Dug. Cost of well, $50. Cost of windmill, $200. See log, p. 149.

TABLE 5.—*Analyses of underground waters from Bibb County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1		White Elk Spring.	Macon, 7 miles east of post office.	Lower Cretaceous.		J. F. Sellers.[a]
2	Dec. 30, 1912	do	do	do		Edgar Everhart.
3		Well of J. B. Willis.	Walden, near	do	250–265	A. M. Lloyd.[b]

No.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	1.5	0.18	0.2	1.3	0.2	2.0	0.2	.....	5.2	3.1	.....	0.8	.....	16	Free CO_2=0.8. See data, pp. 149–150.
2	6.0	.5	.....	1.5	1.2	3.5		0.0	5.0	4.0	5.0	2.0	.....	21	
3	8.8	[c] 2.5		1.6	.5	1.6	1.0	3.9	.....	1.2	.....	1.6	0.5	23	Well No. 3, Table 4.

[a] Expressed by analyst in grains per gallon and hypothetical combinations; recomputed to parts per million and ionic form at U. S. Geol. Survey.
[b] Georgia Geol. Survey Bull. 15, p. 57, 1908.
[c] Fe_2O_3+Al_2O_3.

BLECKLEY COUNTY.

Since this report was transmitted for publication a part of Pulaski County has been organized as Bleckley County. This area is described under the heading Pulaski County, on pages 359–362.

BROOKS COUNTY.

GENERAL FEATURES.

Brooks County is in the extreme southern part of the State, along the Florida border. Its area is 514 square miles and its population is 23,832 (census of 1910). The county is rich agriculturally and also produces lumber and naval stores. The principal manufacturing plants are at Quitman, and include a cotton mill, fertilizer factories, cottonseed-oil mills, and an ice factory.

TOPOGRAPHY.

The northern part of the county is generally level with, however, some gently rolling or slightly broken land. The southern part of the county, south of Quitman, is rolling to hilly, and lime sinks and ponds are more common than in the north. This part of the county is embraced in the southern lime-sink region (pp. 34–35) of the Coastal Plain of Georgia. The principal streams are Withlacoochee and Little rivers and Ocopilco Creek, all of which are sluggish dark-water streams originating in the Coastal Plain. Withlacoochee and Little rivers are bordered by two narrow fluviatile terrace plains, the first lying 12 to 15 feet and the second 35 to 40 feet above low water. The rivers are not bordered by swamps but flow canal-like through the first terrace plain.

The known elevations with reference to sea level are Quitman, 173 feet; Dixie, 130 feet; and water level, Withlacoochee River, Atlantic Coast Line Railroad bridge, 81 feet. From an estimate based on elevations along the Georgia Southern & Florida Railway, in Lowndes and Berrien counties, the higher land in the northern part of the county probably reaches 250 feet above sea level.

GEOLOGY.

The undifferentiated Oligocene to Pleistocene deposits and the Alum Bluff and Chattahoochee are the surficial formations of the county everywhere except along Withlacoochee and Little rivers, on which thin Pleistocene terrace deposits appear. The waters of the shallow wells come from the formations named. Irregularly bedded sands and clays constitute the surface material over much of the county but are not so thick as they are farther north, having been largely removed by erosion along the streams and in the southern part of the county, where the soils are derived from the Alum Bluff formation. The Alum Bluff formation, which consists principally of fine-grained, drab or gray, unctuous or slick clays interbedded with sands, is the source of the water in some of the shallow wells but probably will not yield artesian supplies. The Chattahoochee formation, which underlies the Alum Bluff formation, consists prin-

A. WADE SPRING, 7 MILES EAST OF QUITMAN, BROOKS COUNTY.

This is a limestone spring having an estimated yield of 15,000,000 gallons a day. Photograph by S. W. McCallie.

B. SMALL RICE AND LUMBER MILL AT TARBORO, CAMDEN COUNTY, OPERATED BY THE COMBINED FLOW OF THREE ARTESIAN WELLS.

Photograph by S. W. McCallie.

LOCAL SUPPLIES.

Quitman (population 3,915, census of 1910).—Artesian wells are the principal source of water supply.

J. W. Spencer [1] gives the following partial log of the first well (No. 5, Table 6), drilled in 1884 at the Quitman waterworks plant.

Partial log of first municipal well at Quitman.

	Thickness.	Depth.
	Feet.	*Feet.*
Clay and sand	70	70
Soft rock in seams	30	100
Rock, 3 feet, after which the drill fell 6 feet into a stream of water	9	109
Soft rock and sand, with a thin layer of hard flint rock at base	77	186
Quicksand and hard rock in beds 1 to 3 feet thick	114	300
Sand and clay	40	340
Sand	45	385

The water rose from 109 feet to within 30 feet of the surface.

A well (No. 6, Table 6)[2] drilled in 1903 to a depth of 321 feet at the waterworks plant at Quitman furnished the municipal water supply until 1910. Two water-bearing beds are said to have been encountered, one at 123 feet and the other at 310 feet. An analysis of the water from the 310-foot stratum is given in Table 7 (analysis 2).

In 1910 a third well (No. 3, Table 6) was drilled, which now furnishes the municipal water supply. This well is 699 feet deep and 10 inches in diameter. It yields 400 to 500 gallons of water per minute by pumping without perceptibly lowering the static head. The water used comes from beds below 650 feet, the upper water-bearing beds having been cased off. These beds are probably in the Jackson formation of the Eocene. The following record of the well has been furnished by J. M. Curtwright, superintendent of the city water and light department:

Log of well drilled at the new water and light plant, Quitman.

[Authority, C. E. Edwards.]

	Thickness.	Depth.
	Feet.	*Feet.*
Varicolored clay	25	25
Yellow sand	18	43
Yellow clay	32	75
Yellow sand	10	85
"Soapstone" or "talc" (unctuous clay)	15	100
Gray mud and sand; thin layer of flint at base	15	115
Brown limestone and flint	44	159
Very hard brown rock and flint	31	190
White limestone, water bearing at 318 feet (bold stream)	110	300
Brown flinty rock	25	325
White limestone	11	336
Brown flint, water bearing at 340 and 355 feet (bold streams)	24	360
Gray limestone and bowlders of flint, water bearing at 440, 647, and 685 feet (bold streams at last two depths)	339	699

[1] Georgia Geol. Survey First Rept. Progress, p. 74, 1891.

[2] U. S. Geol. Survey Water-Supply Paper 110, pp. 45–54, 1905.

An analysis of water from the 699-foot well is given in Table 7 (analysis 1).

Several private wells in and near Quitman, most of them less than 350 feet deep, probably draw from the Chattahoochee formation.

Barwick (population 381, census of 1910).—The village of Barwick has no public water-supply system. Water for domestic use is obtained from dug and bored wells 25 to 60 feet deep, which, as a rule, yield abundant soft water. A bored well 50 feet deep (No. 1, Table 6), owned by the Farmers' Ginning Co., is reported to yield 100 gallons a minute by pumping.

Morven (population 383, census of 1910).—At Morven, water is obtained mainly from dug and bored wells 18 to 50 feet deep and from two wells 150 to 200 feet deep. The water of the shallow wells is soft, but that of the deep wells is said to contain considerable lime and probably comes from the limestone beds of the Chattahoochee formation. (See well No. 2, Table 6.)

TABLE 6.—*Wells in Brooks County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Barwick	Farmers' Ginning Co.		C. T. Headley	1907	.....
2	Morven			C. B. Meadows	.....	.....
3	Quitman	City	C. E. Edwards	J. M. Curtwright	1910	173
4	Quitman, ¾ mile northwest of, at Oglesby mill.	.....	.....	S. W. McCallie [a]	1903	.....
5	Quitman (near pumping station).	City	.....	S. W. McCallie [a b]	1884	173
6	Quitman (near depot)	.....do	.....	.....do	1903	173
7	Quitman (near Russel Pond)	.....do	.....	.....do	1905	173
8	Quitman, 2 miles northeast of.	Quitman Power Co.	.....	S. W. McCallie [a]	1905	.....

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute by pumping.	How obtained.	Quality.
		Inches.	*Feet.*	*Feet.*	*Feet.*	*Galls.*		
1	50	8	.....	.....	30	100	Deep-well pump	Soft.
2	200?	.....	.....	.....	(c)	.....	.....	Hard.
3	699	10	650–699	(d)	77	400	.....	Analysis 1, Table 7.
4	92	6	87	.....	48	.....	.....	
5	500	6	.....	.....	.....	.....	.....	
6	321	.....	310	123	77	.....	.....	Analysis 2, Table 7.
7	120	.....	120	.....	77	.....	.....	
8	90±	10(?)	80±	.....	.....	.....	.....	

[a] Georgia Geol. Survey Bull. 15, pp. 58–60, 1908.
[b] U. S. Geol. Survey Water-Supply Paper 110, pp. 45–54, 1905.
[c] Nonflowing.
[d] See log, p. 154.

TABLE 6.—*Wells in Brooks County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic and boiler supply.	Alum Bluff formation?		
2	Domestic	Chattahoochee formation?		There is another similar well at this place.
3	Municipal supply.	Jackson formation?	Limestone	See log, p. 154.
4	Boiler supply	Alum Bluff formation.	Sand	
5	Municipal supply.	Vicksburg formation?	Limestone	Cost of well, $3,000. See log, p. 154.
6		Chattahoochee formation?	Sand	
7	Drainage			Used for draining ponds.
8	do			Do.

TABLE 7.—*Analyses of artesian waters from Quitman.*

[Parts per million.]

	1	2
Silica (SiO_2)	17	28
Iron (Fe)	.2	13
Aluminum (Al)		2.6
Calcium (Ca)	39	23
Magnesium (Mg)	9.4	9.1
Sodium (Na)	4.9	4.1
Potassium (K)	3.7	.7
Carbonate radicle (CO_3)		.0
Bicarbonate radicle (HCO_3)	154	120
Sulphate radicle (SO_4)	3.8	Trace.
Chlorine (Cl)	4.6	5.8
Total dissolved solids	159	153
Free carbon dioxide (CO_2)		90

1. Well No. 3, Table 6. Depth of principal water-bearing bed, 650-699 feet. Edgar Everhart, analyst.
2. Well No. 6, Table 6. Depth of principal water-bearing bed, 310 feet. Edgar Everhart, analyst (Georgia Geol. Survey Bull. 15, pp. 59-60, 1908).

BRYAN COUNTY.

GENERAL FEATURES.

Bryan County is one of the seacoast counties in the southeastern section of the Coastal Plain of Georgia. Ogeechee River forms its eastern boundary and Canoochee River its western boundary from the northwestern corner southeastward for about 20 miles, whence it flows eastward and divides the county into two parts. The area of the county is 431 square miles and its population is 6,702 (census of 1910). There are no cities or large towns and water is not used extensively for industrial purposes. Lumber and naval stores are the chief products.

TOPOGRAPHY.

The southern half of the county, embracing practically all the land lying south of Canoochee River, is a terrace plain 10 to 30 feet above sea level. From the western edge of this lower plain, which lies

within the physiographic division known as the Satilla coastal lowland (see pp. 36–38), the land gradually rises to the Okefenokee plain, 40 to 100 feet above sea level, and the plain to the Altamaha upland, of which the northern third of the county forms a part. The greater part of the county is poorly drained and is swampy. A considerable area of salt marsh lies adjacent to the mouth of Ogeechee River, and tide-swamp land extends upstream several miles beyond the salt marsh proper. Small ponds supporting a growth of cypress or gum characterize the higher plain.

GEOLOGY.

The surface deposits are sands and clays or silts, mainly of Pleistocene age, but in the northwestern part of the county are surficial materials which are mapped as undifferentiated Oligocene to Pleistocene, inclusive. In the surficial formations the water table stands within a few feet of the surface and is obtained in wells 10 to 30 feet deep. The Pleistocene and undifferentiated deposits are thought to be not more than 50 feet thick. Beneath the surficial deposits are strata of probable Miocene age, and beneath the Miocene are other strata of probable upper Oligocene age, referable to the Alum Bluff formation. The combined thickness of the Miocene and the Alum Bluff formation probably does not exceed 250 or 300 feet. These formations consist mainly of sands and clays with subordinate beds of hard rock. The Alum Bluff formation is underlain by several hundred feet of soft porous limestones, shell marls, and calcareous sands and clays, which may represent in descending order the Chattahoochee and Vicksburg formations of the Oligocene and the Jackson formation of the Eocene. The limestones are important aquifers and in the southern and eastern portions of the county, at depths of 300 to 450 feet, may be expected to yield abundant supplies of water which will flow at the surface. Beneath the limestones are marls and sands of Eocene age, probably aggregating a thickness of 1,000 feet or more. Strata of Cretaceous age underlie the Eocene at depths of 1,500 to 1,800 feet or more, but nothing definite is known concerning them; at an undetermined depth they probably rest upon ancient crystalline basement rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The shallow wells of the county, which are mainly of the driven type and 10 to 30 feet deep, furnish soft waters, all of which are not wholesome. The few seepage springs are of relatively slight importance.

Many artesian wells, most of them less than 500 feet deep, are scattered throughout the county. They yield moderately hard

waters suitable for domestic and for most industrial purposes and of much better quality for drinking than waters from other sources.

Except in the northwestern part of the county the conditions are favorable for obtaining artesian flows. (See map, Pl. XVIII, p. 122.) It has not been possible to collect information regarding all wells in the county, but the few descriptions and analyses given on the following pages are typical and give a fair idea of the artesian conditions and the quality of the waters.

LOCAL SUPPLIES.

Ways (population 131, census of 1910).—Within 2 miles of Ways there are nine flowing wells from 320 to 460 feet deep. They draw from two water-bearing beds, one lying at about 300 feet and having weak flows and the other lying at about 400 feet and furnishing strong flows with a head of 30 to 35 feet above the surface. No thick beds of hard rock have been reported, the strata consisting mainly of sand and greenish or drab sandy clay. The wells are commonly cased to 70 or 100 feet. The artesian waters are moderately hard but are suitable for general domestic uses. (See Nos. 12 to 14, Table 8.)

Keller.—Keller, near which there are several flowing wells, is a small village about 8 miles south of Ways and about 15 feet above sea level. According to E. D. Cory, the driller, the public well (No. 6, Table 8) completed in 1895 is 325 feet deep and 2 inches in diameter. The principal water-bearing bed is limestone at 310 feet, but water was also found in gravels at 40 and 90 feet. When first drilled the water rose 18 feet above the surface, but it now rises only 6 feet above. The water is sulphurous but is used for domestic purposes. The following log of the public well has been obtained:

Log of town well at Keller (No. 6, Table 8).

	Thickness.	Depth.
	Feet.	*Feet.*
Sand	20	20
Mud and gravel	30	50
Greenish marl (clay) and sand	20	70
Shale rock	2	72
Sand, shale rock, and hard marl	238	310
Limestone, water bearing	15	325

A well (No. 5, Table 8) belonging to P. D. Cory, about 300 yards southeast of the public well, is 318 feet deep. Sand and alternate layers of sand and marl with shells were penetrated to 270 feet. The water-bearing bed is reported to be below 300 feet.

A well (No. 7, Table 8) owned by George W. Corson, one-half mile southwest of Keller, is reported to be 340 feet deep. The water rises 18 feet above the surface.

In a well (No. 8, Table 8) owned by J. A. Smith, 2 miles south of Keller, the principal water-bearing bed is at 320 feet. Rock was entered at 310 feet. The water rises 10 feet above the surface.

There are several other wells at Keller, but no information concerning them was obtained.

Fort McAllister.—Fort McAllister is on Bayou Neck on the west bank of Ogeechee River, 7 miles southeast of Ways, and is the site of an old fort dating back to the Revolutionary War and to Indian times. In former days there were large plantations in this vicinity, but now the population is sparse. There are three artesian wells on the old Ward plantation. Mr. Sibley, who lives on the place, states that these wells were drilled in 1891–1893 for irrigating rice fields and for general plantation uses. Two of them are 6 inches and one is 8 inches in diameter. The 8-inch well is variously reported as 700 feet deep and as 1,800 feet deep. One of the 6-inch wells is 900 feet deep; the depth of the other was not ascertained. The 8-inch well (No. 3, Table 8) yields an enormous amount of water which, however, is not at present used. Shortly after the completion of the well a storm overturned the scaffolding about the casing, breaking the pipe 10 or 12 feet below the surface, and the break was never repaired. The water "boils" up in great quantities and has formed a "well spring" or basin 10 or 12 feet deep, from which it flows out through the marsh and into Ogeechee River. It is difficult to estimate the flow but it probably exceeds 1,500 gallons per minute. There has been no apparent decrease in the yield since the completion of the well.

A 900-foot well is located on the public road near the bank of Ogeechee River in the vicinity of Fort McAllister. (See analysis 1, Table 9.)

Artesian flows are also obtained in this vicinity at depths less than those already described. One such well (No. 4, Table 8) on the farm of Mrs. M. C. Williams on Genesis Cape, a short distance from the Ward plantation, is only 198 feet deep.

Pembroke (population 467, census of 1910).—Pembroke is on the Seaboard Air Line Railway in the northwestern part of the county, 101 feet above sea level. The domestic water supply is derived in part from driven and dug wells 15 to 30 feet deep and in part from deep wells. In 1909 the town completed an artesian well 475 feet deep (No. 10, Table 8), from which some of the people obtain water for domestic use and for stock. The water rises to within 20 feet of the surface.

Mayor J. O. Strickland, has furnished the following information concerning a deep well from which the greater part of the population obtains water for domestic use:

The well (No. 11, Table 8) is 100 yards west of the post office and is owned by U. S. Williams. It is 520 feet deep and 6 inches in diameter and was drilled in 1906 at a cost of $625. Ten-inch casing was inserted to 125 feet, 8-inch casing to 350 feet, and 6-inch casing to 500 feet. Water-bearing beds were found at 120, 250, 350, and 520 feet. The water from the 520-foot stratum, the principal water-bearing bed, rises to within 21 feet of the surface, and is lifted to the surface by a force pump operated by a gasoline engine.

Mr. Williams's well probably taps a water-bearing bed of Eocene age. (See analysis 2, Table 9.)

Clyde (population 107, census of 1910).—Clyde, the county seat, has two artesian wells, one of which (No. 2, Table 8) was drilled in 1898 by the county and is 290 feet deep. At 4 feet above the surface it furnishes a flow of sulphurous water, which is said not to have decreased.

Roding.—Three artesian wells are reported at Roding, 3 miles south of Clyde.

Ossabaw Island.—Several flowing wells at Ossabaw Island are reported to be 300 to 500 feet deep.

Belfast.—There are two flowing wells at Belfast, one of which (No. 1, Table 8) is reported to be 450 feet deep. The wells are used by a lumber company for boiler supply, and by the people of the village for domestic uses.

TABLE 8.—*Wells in Bryan County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Belfast	A lumber company		E. D. Cory		15
2	Clyde	County	E. D. Cory	Albert Wise	1898	
3	Fort McAllister (Bayou Neck).	Ward plantation		Mr. Sibley	1891-93	
4	Fort McAllister	Mrs. M. C. Williams				
5	Keller	P. D. Cory		P. D. Cory		
6	do	Public	E. D. Cory	E. D. Cory	1895	15
7	Keller (½ mile southwest).	G. W. Corson	A. E. Cory	G. W. Corson	1908	340
8	Keller (2 miles south).	J. A. Smith	E. D. Cory	J. A. Smith		
9	Ossabaw Island					
10	Pembroke	Town	E. M. Haywood & Co.	W. K. Smith	1909	101
11	do	U. S. Williams	do	J. O. Strickland, mayor.	1906	101
12	Ways (½ mile west of Ogeechee River).	Seaboard Air Line Railway.		S. W. McCallie[a]	1895	18
13	Ways	Bailey Carpenter		do		18
14	Ways (2 miles southeast).[a]	R. A. Raines	Paul T. Haskell.	Driller	1909	9

[a] Georgia Geol. Survey Bull. 15, pp. 60-62, 1908.

TABLE 8.—*Wells in Bryan County*—Continued.

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	450	.....	.....	.....	.....	.....	.....	Flows.....	
2	290	3	290	.....	+ 4	12	.....	.....	Sulphurous.
3	700? 1,800?	6 6 8	.....	.....	.....	1,500- 2,000	.....	Flows.....	
4	198	.....	.....	.....	.....	.....	.....	.....do.....	
5	318	.....	300	.....	.....	.....	.....	.....do.....	
6	325	2	310	40 90	+ 6	20	.....	.....	Do.
7	340	2½	.....	.....	+18	.....	.....	.....	Do.
8	320?	.....	320	.....	+10	.....	.....	.....	Do.
9	.....	.....	.....	.....	.....	.....	.....	.....	
10	475	4	.....	.....	−20	.....	.....	Pumped by hand.	
11	520	6	520	120 250 350	−21	.....	.....	Gasoline engine...	See analysis 2, Table 9.
12	460	3	440	340	+20	.....	.....	.....	Hard.
13	345	1½	.....	.....	+25	.....	.....	.....	Do.
14	350	2	340	.....	+36	.....	.....	Flows.....	

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic, boiler supply.	Tertiary.....	Rock.....	Two wells.
2	Domestic.....	.....do.....	.....	Do.
3	Domestic, irrigation.	Tertiary?.....	.....	Three wells.
4	.....	Tertiary.....	.....	
5	Domestic.....	.....do.....	.....	
6	.....do.....	.....do.....	Limestone.....	Water formerly rose 18 feet above surface. Cost of well, $125. See log, p. 158.
7	.....do.....	.....do.....	.....	Cost of well, $150.
8	.....do.....	.....do.....	.....	Eight or more wells.
9	.....	.....	.....	Several wells.
10	Domestic.....	Tertiary.....	.....	
11	.....do.....	.....do.....	Sand.....	Cost of well, $625. Cost of machinery, $1,200. See also p. 160.
12	Boiler supply, domestic.	Eocene?.....	.....	
13	Domestic.....	.....do.....	.....	
14	.....do.....	.....do.....	Sand.....	Water fluctuates with tide.

TABLE 9.—*Analyses of well waters from Bryan County.*

[Parts per million.]

	1	2
Silica (SiO_2)	31	34
Iron (Fe)	.4	2.0
Calcium (Ca)	29	22
Magnesium (Mg)	15	8.0
Sodium and potassium (Na+K)	10	22
Carbonate radicle (CO_3)	.0	.0
Bicarbonate radicle (HCO_3)	166	140
Sulphate radicle (SO_4)	Trace.	8.0
Nitrate radicle (NO_3)	.....	3.0
Chlorine (Cl)	8.0	10
Total dissolved solids	206	171

1. Well 900 feet deep, near Ogeechee River near Fort McAllister, 7 miles southeast of Ways. Age of water-bearing bed, Tertiary. Sample collected Apr. 12, 1911. Edgar Everhart, analyst.
2. Well No. 11, Table 8. Sample collected Dec. 17, 1912. Edgar Everhart, analyst.

BULLOCH COUNTY.

GENERAL FEATURES.

Bulloch County is in the east-central part of the Coastal Plain of Georgia. Statesboro, the county seat, is 54 miles by railroad northwest of Savannah. The area of the county is 887 square miles and its population is 26,464 (census of 1910). The chief industries are agriculture and the production of lumber and naval stores. Surface and underground waters are used for boiler supply by many sawmills and cotton gins and by small manufacturing concerns at Statesboro.

TOPOGRAPHY.

The southern part is flat and poorly drained; the northern part is more elevated and is gently rolling or undulating. The transition from one part to the other is not sharply defined. The approximate line of separation runs from Ogeechee River, opposite Egypt, southwest across the county to Canoochee River, a short distance above Groveland, Bryan County. On the southern plain bays are common and small branches or creeks spread out through dense swamps without well-defined channels. Although no accurate figures are available the elevations in the rolling section in the north are probably from 200 to 250 feet above sea level. A swamp, which fringes Ogeechee River and is in places a mile or more wide, is the lowest elevation in the county, being not more than 40 or 50 feet above sea level in the extreme southeast. It is bordered by two relatively narrow terrace plains, one lying 8 to 10 feet and the other 30 to 40 feet above it.

GEOLOGY.

Throughout the greater part of the county, except in a narrow area bordering Ogeechee River, the surface materials comprise ferruginous argillaceous sands and drab sandy clays, weathering to gray or yellow residual quartz sands. These surface deposits and the thin Pleistocene deposits of sand and clay on the river terraces and flatwoods lands in the southern part of the county are the source of the waters obtained from shallow wells. The Alum Bluff formation outcrops in the narrow area of lowland bordering Ogeechee River, and doubtless is present beneath the surface materials throughout the entire county. The Alum Bluff formation, which probably does not exceed 200 feet in thickness and is in many places probably much thinner, is underlain by a series of undifferentiated limestones, sands, clays, and marls, which in descending order are of Oligocene, Eocene, and Cretaceous age. At an undetermined depth, probably 2,000 feet or more, the Cretaceous deposits rest upon a basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Shallow wells 10 to 40 feet deep furnish the chief water supplies for domestic use in the villages and rural districts.

There are small seepage springs throughout the county but most of them are located on the edges of swamps, and some of them are unfit for domestic use.

The spring waters usually have a strong taste of iron and where the waters come in contact with decaying vegetation an iridescent film of iron oxide, sometimes mistaken for oil, forms on the surface. An analysis of water from a small spring located 3½ miles southwest of Register and owned by J. W. Atwood is given in Table 10 (analysis 1). This water is probably typical of the spring waters.

The only deep wells reported in the county are at Statesboro.

Flowing artesian wells can probably be obtained in the lowland bordering Ogeechee River at elevations of 100 to 130 feet above sea level, for such wells have been obtained at these elevations at Rockyford and Dover in the adjoining county of Screven. It is also probable that flows can be obtained on the lowest land bordering Canoochee River. An abundant supply of water may be expected anywhere in the county at depths of 500 or 600 feet. Water-bearing beds of Cretaceous age probably exist at depths of 1,000 feet or more.

LOCAL SUPPLIES.

Statesboro (population 2,529, census of 1910).—Statesboro, the only town in the county having a water-supply system, obtains water from two artesian wells. No detailed information has been obtained concerning the older of the two wells, but the second (drilled in 1912) is 555 feet deep and penetrates water-bearing strata between 400 and 555 feet. This well was drilled by the Hughes Specialty Well Drilling Co., of Charleston, S. C., from which company the data here given, including the log, were obtained. Ten-inch casing extends to 40 feet and 8-inch casing to 320 feet.

Log of town well No. 2, at Statesboro.

[Authority, J. R. Connelly, driller in charge, 96 Ashley Avenue, Charleston, S. C.]

	Thickness.	Depth.
	Feet.	*Feet.*
Soft yellow sand and clay in alternate layers	40	40
Light-colored hard sandstone	30	70
Light-colored soft sand	10	80
Light-colored marl and sand	20	100
Light-colored chalky material	20	120
Light-colored tough rock	20	140
Light-colored soft sand	20	160
Tough light-colored rock and sand in alternate layers	60	220
Light-colored hard rock	20	240
Tough light-colored rock and sand in alternate layers	40	280
Soft white chalky material	50	330
Hard white rock	30	360
Medium-hard white sand and rock in alternate layers	40	400
Medium-hard dark-brown shell rock, water bearing	60	460
Light-brown shell rock with interbedded hard layers, water bearing	95	555

The record is not sufficient to permit the correlation of the strata, but the well may have completely penetrated the Oligocene and have entered the upper part of the Eocene.

There are several other artesian wells at Statesboro, but no detailed information concerning any one of them has been obtained. An analysis of the water from a well 320 feet deep, owned by W. D. Davis, is given in Table 10 (analysis 2).

TABLE 10.—*Analyses of waters from Bulloch County.*

[Parts per million.]

	1	2
Silica (SiO_2)	4.8	43
Iron (Fe)	3.5	[a] 5.0
Aluminum (Al)	.2	.....
Calcium (Ca)	1.1	1.5
Magnesium (Mg)	.6	.8
Sodium (Na)	4.5	2.9
Potassium (K)	.3	2.7
Carbonate radicle (CO_3)	.....	.0
Bicarbonate radicle (HCO_3)	74	3.4
Sulphate radicle (SO_4)	.9	3.4
Chlorine (Cl)	6.3	6.8
Total dissolved solids	29	69
Free carbon dioxide (CO_2)	.....	3.0

[a] $Fe_2O_3+Al_2O_3$.

1. Spring of J. W. Atwood, 3½ miles southwest of Register. Age of water-bearing bed, Oligocene? Analyzed December, 1909; Edgar Everhart, analyst.
2. Well of W. D. Davis at Statesboro; depth 320 feet. Edgar Everhart, analyst (Georgia Geol. Survey Bull. 15, p. 62, 1908).

BURKE COUNTY.

GENERAL FEATURES.

Burke County is in the northeastern part of the Coastal Plain of Georgia. Waynesboro, the county seat, is 32 miles south of Augusta. The area of the county is 956 square miles and its population is 27,268 (census of 1910). Agriculture is the principal industry.

TOPOGRAPHY.

The county lies in the topographic division of the Coastal Plain known as the fall-line hills (pp. 29–31). The surface is, in part, moderately broken or hilly and in part nearly level. The streams have cut valleys 50 to 150 feet deep, but erosion has not advanced to maturity and relatively broad flat ridges or small plateaus exist between the water courses. The principal streams of the county are Savannah River, the second largest stream in the State, which forms the eastern boundary, Ogeechee River, which forms the southwestern boundary, and Briar Creek. Savannah River, which is navigable from Augusta to the sea, has cut its valley about 150 feet below the level of the upland plain to the west and is in places bordered by high steep bluffs. As it rises in mountainous regions and flows through the Piedmont Plateau, its water is more or less muddy during the greater part of the year. Ogeechee River rises in the Piedmont Plateau, but its water is not always muddy and throughout the lower part of its course it resembles streams originating in the Coastal Plain. The river flows through a wide, dense swamp and has few bluffs. Above the swamp is a habitable terrace plain upon which abundant flows of artesian water are obtained. Briar Creek, a clear stream of considerable size, flows southeastward through the county.

Lime sinks and ponds occur on the comparatively level areas in the southwestern and southeastern parts of the county, but they are not abundant and are not characteristic of the topography as a whole.

The known elevations above sea level are at Waynesboro, Central of Georgia Railway station, 286 feet; Shell Bluff Landing, low water, 87 feet, top of bluff, 237 feet; Midville, 186 feet; and Keysville (rough estimate), 400 feet.

GEOLOGY.

The surface materials belong mainly to the Claiborne group, which is divisible into the McBean formation and the Barnwell sand. The McBean formation, which consists of 300 or 350 feet of sands, marls, clays, and limestones that outcrop along the streams, is an important source of water both in this and adjoining counties. The water-bearing beds are believed to be of local extent, for the strata, as seen in natural outcrops, lack constant lithologic characters. The Barnwell sand overlies the McBean formation and is the surface formation over the greater part of the county. It consists of red, highly ferruginous sands and mottled argillaceous sands, in which there are thin beds of sandstone and quartzite and fragments of flint.

The Claiborne group is underlain by Cretaceous sands and clays, which in the northern part of the county along Briar Creek, McBean Creek, and Savannah River probably lie 100 to 250 feet beneath the surface and which from Waynesboro southward would lie at depths

of 350 to 500 feet. Igneous and metamorphic rocks, which will probably be found at depths of 1,000 to 1,500 feet, form the basement upon which the Cretaceous deposits rest.

The Claiborne group is overlain in relatively small areas in the central and southeastern parts of the county by sand and some gravel of undetermined age. The Central of Georgia Railway passes over these deposits from Waynesboro to the southern boundary of the county, and similar deposits have been recognized in the vicinity of Girard and Sardis.

Gray or yellow residual sands are prominent at the surface at a number of places but do not attain any considerable thickness. These sands are conspicuous near Keysville, Girard, and on the upland along Savannah River.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The main sources of domestic water supply are shallow dug and bored wells 30 to 75 feet deep. Water from many of the shallow wells is considered unwholesome, but the poor quality is probably due to contamination resulting from improper construction of the wells rather than to harmful inorganic constituents. In some parts of the county the shallow wells penetrate calcareous materials and the waters are hard.

Streams and ponds furnish an abundance of water for stock and for other purposes.

Springs are of local importance as sources of domestic supply. Several limestone springs, each of which yields large quantities of hard water, occur in the western and eastern parts of the county. Davis Spring, a mile west of Gough, is reported to yield sufficient water to operate a small gristmill. Many small springs throughout the county furnish pure water. An analysis of water from Cox Spring, located 1 mile northeast of Shell Bluff post office, is given in Table 12 (analysis 1).

Throughout the county abundant potable water can be obtained by deep wells from either the Claiborne group or the underlying Cretaceous sands, the latter of which will probably yield soft waters. Flowing artesian wells have been obtained in the vicinity of Midville and in the valley of a tributary of Briar Creek near Waynesboro; it is probable that flows can also be obtained along the lowlands bordering McBean Creek, Briar Creek, and Savannah River in the eastern part cf the county.

LOCAL SUPPLIES.

Waynesboro.—Waynesboro, the county seat, has a population of 2,729 (census of 1910). The city owns a public water-supply system which draws from an artesian well on low ground near the Central of

Georgia Railway station. The well (No. 7, Table 11) is about 300 feet deep and flows 25 gallons a minute a few feet above the surface. The water is slightly hard but has proved satisfactory for general domestic purposes.

According to Fuller and Sanford,[1] a well (No. 8, Table 11) owned by J. I. Linler, on low ground a quarter of a mile east of Waynesboro, is 249 feet deep, 6 inches in diameter, and flows 20 gallons per minute at 4½ feet above the surface. The principal water-bearing bed is at a depth of 160 feet.

The following information relating to wells at Waynesboro is quoted from a report by McCallie:[2]

There are two deep wells at Waynesboro, one owned by Mr. W. A. Wilkins [No. 5, Table 11], and the other by the Southern Cotton Seed Oil Co. [No. 6, Table 11]. The former well, which was put down in 1888, is reported to have a depth of 889 feet. Water-bearing strata are said to occur in this well at depths of 250, 300, and 889 feet. The water supply at present is obtained from the upper stratum. The water rises to within 14 feet of the surface and is said to be of good quality.

Mr. R. G. Edenfield of Augusta, Ga., has furnished the writer with a number of samples of borings from this well on which the following notes have been made:

[*Log of well of W. A. Wilkins at Waynesboro (No. 5, Table 11).*]

	Feet.
Fine red sand to	60
Yellow sand to	150
Coarse white sand with fragments of shells to	230
Rather coarse gray sand to	240
Sandy marl to	290
Fine yellow sand to	310
Very coarse sand with dark-colored pebbles, numerous minute crystals of gypsum, and fragments of tough gray clay to	340
Coarse sand to	360
Dark sandy clay with sharks' teeth to	380
Coarse sand to	410
The same as above to	500
Coarse sand, mixed with red micaceous clay to	700

Considerable limestone and flint are reported to occur in the Wilkins well; but their depth from the surface and the thickness could not be ascertained.

The Southern Cotton Seed Oil Co.'s well [No. 6, Table 11] has a depth of about 200 feet. It is 6 inches in diameter and furnishes daily by pumping 1,200 gallons of water, which supplies the oil mill and a number of residences in the town. The water rises to within 19 feet of the surface and is of good quality.

An analysis of water from the Southern Cotton Seed Oil Co.'s well is given in Table 12 (analysis 2).

The well of W. A. Wilkins at Waynesboro (depth, 889 feet) undoubtedly completely penetrates the Claiborne group and enters the upper part of the Cretaceous. The thickness of the Claiborne group at Waynesboro is believed not to exceed 500 feet, this opinion being based on the evidence furnished by the well borings from Mr. Wilkins's well.

[1] U. S. Geol. Survey Bull. 298, p. 50, 1908. [2] Georgia Geol. Survey Bull. 15, pp. 63, 64, 1908.

Midville (population 603, census of 1910).—Midville, the second largest town in the county, is on the Central of Georgia Railway near Ogeechee River, in the southwestern part of the county. The town has no public water-supply system but has one public flowing well and many private flowing wells, which furnish the principal supplies for domestic use. The artesian waters are sulphurous and emit a rather pronounced odor of hydrogen sulphide, but are clear and potable. They are moderately hard, for they contain calcium carbonate, for which reason river water is preferred for use in boilers.

The artesian wells range in depth from 157 to 750 feet and yield strong flows, the maximum yield reported being 75 gallons per minute. The static head in the various wells ranges from 14 to 47 feet above the surface. According to reports, water-bearing beds have been entered at 50, 150, 190, 200, 295, 300, 450, and 700 feet.

The deepest well (No. 4, Table 11) concerning which information has been obtained is owned by A. W. Jones, who states that it is 750 feet deep and flows 75 gallons per minute and that the water will rise 47 feet above the surface. The principal water-bearing bed is at 700 feet; other water-bearing beds are found at 200, 300, and 450 feet. An attempt was made several years ago to utilize the combined pressure of this and two other wells in operating a small electric-light plant, but the power was found to be inadequate.

McCallie[1] has published the following log of the public well at Midville:

Log of public well at Midville.

	Thickness.	Depth.
	Feet.	*Feet.*
Soil	10	10
White sand	25	35
Limestone, with underground stream of water	20	55
Limestone, pebbles with shells and sharks' teeth	50	105
Limestone, with an underground stream of water	6	111
Honeycombed water-bearing rock	46	157

The water-bearing beds tapped by most of the wells at Midville are in the Claiborne group. With the exception of the 750-foot Jones well (No. 4, Table 11) probably none of them reach the Cretaceous.

Greens Cut.—At Greens Cut a well owned by H. C. Reese, drilled in 1907, is reported to be 289 feet deep and 3 inches in diameter and is cased to a depth of 200 feet. The water, which is derived principally from a gravel bed at a depth of 280 feet, rises to within 77 feet of the surface and is hard and unsuitable both for laundry and boiler-supply purposes but is clear and is a good drinking water.

[1] Georgia Geol. Survey Bull. 15, p. 65, 1908.

A well owned by W. E. Rhodes, located 5 miles west of Greens Cut, is reported to be 290 feet deep.

Gough.—At Gough, private wells from 30 to 75 feet deep are the main source of supply. A well at this place, drilled to a depth of 400 feet, in which water rose to within 45 feet of the surface, has been abandoned on account of the entrance of sand into the boring.

Girard (population 227, census of 1910).—At Girard several nonflowing artesian wells range in depth from 200 to 300 feet. The prospects of obtaining artesian flows on the terrace bordering Briar Creek near Girard are good. The town has no public water supply and water is obtained chiefly from dug wells 30 to 40 feet deep.

TABLE 11.—*Wells in Burke County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Elevation above sea level or below datum.
						Feet.
1	Girard (near)					
2	Gough					
3	Greens Cut	H. C. Reese			1907	+280
4	Midville	Allen W. Jones	W. H. Brown	Allen W. Jones	1901	+186
5	Waynesboro	W. A. Wilkins		R. G. Edenfield	1888	+286
6	do	Southern Cotton Seed Oil Co.		S. W. McCallie[a]		+286
7	do	City		W. E. Fambrough		+286
8	do	J. I. Linler	H. F. Loyd, Millen, Ga.	Owner[b]	1905	c— 15

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	200, 300								
2	400				−45				
3	289	3	280	250	−77			Windmill and deep well pump.	Hard.
4	750	5	700	200, 300 450	+47	75		Flows	Do.
5	889		250	300, 889	−14				
6	200	6			−19		2		Analysis 2, Table 12.
7	300		300		+ 5	25	150–200	Air lift	Slightly hard.
8	249	6	160		+ 4½	20		Flows	Soft.

[a] Georgia Geol. Survey Bull. 15, pp. 63, 64, 1908.
[b] U. S. Geol. Survey Bull. 298, p. 50, 1908.
[c] Level below railroad track at station.

TABLE 11.—*Wells in Burke County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	.....	Claiborne group...	.....	Nonflowing.
2	.....	Claiborne group?..	.....	Abandoned.
3	Domestic.....	Claiborne group...	White gravel.....	Cost of well, $400; cost of machinery, $225; 3-inch casing extends to a depth of 200 feet.
4	.....do.....	Cretaceous.....	Sand.....	Rock struck at a depth of 550 feet; 5-inch casing to 700 feet. Cost of well, $600.
5	.....	.....	.....	See log, p. 167.
6	Domestic and oil mill.	Claiborne group...	.....	
7	City supply.....	.....do.....	Sand.....	
8	Domestic, manufacture of ice.	.....do.....	Soft rock and sand.	6-inch casing to 125 feet. Cost of well, $500.

TABLE 12.—*Analyses of waters from Burke County.*

[Parts per million.]

	1	2
Silica (SiO_2)	7.4	16
Iron (Fe)	2.8	[a] 6.1
Aluminum (Al)	1.6	.....
Calcium (Ca)	50	62
Magnesium (Mg)	1.3	2.0
Sodium (Na)	1.6	3.6
Potassium (K)	.8	1.7
Carbonate radicle (CO_3)	.....	.0
Bicarbonate radicle (HCO_3)	161	201
Sulphate radicle (SO_4)	.5	3.7
Chlorine (Cl)	5.2	7.0
Total dissolved solids	147	198
Free carbon dioxide (CO_2)	.....	82

[a] $Fe_2O_3+Al_2O_3$.

1. Cox Spring, located a mile northeast of Shell Bluff post office. Age of water-bearing bed, Claiborne. Analyzed in 1907 by Edgar Everhart.
2. Well No. 6, Table 11. Edgar Everhart, analyst. (Georgia Geol. Survey Bull. 15, p. 64, 1908.)

CALHOUN COUNTY.

GENERAL FEATURES.

Calhoun County is in the southwestern part of the Coastal Plain of Georgia, between Flint and Chattahoochee rivers. Its area is 284 square miles and its population 11,334 (census of 1910). Agriculture and the production of lumber and naval stores are the chief industries.

TOPOGRAPHY.

The county is nearly level to slightly rolling. Lime sinks, isolated or connected by streams or swamps are notable. The elevation above sea level is about 150 feet in the southeast corner of the county and about 350 feet in the northwest corner, these being the extremes. The valleys are shallow and the streams have very low banks. In places the channels are clogged by logs and other vegetation and the

water spreads out through broad swamps. The stream divides are as a rule not more than 50 feet above the bottoms of the valleys.

GEOLOGY.

Except in several relatively small areas the county is everywhere directly underlain by the Vicksburg formation. At the surface the materials of the Vicksburg appear as red argillaceous sands, the residual products of weathering, containing both beds and scattered fragments of flint. Soft white limestones are found at depths of 25 to 75 feet. Well drillers report the materials penetrated between the surface and the limestone as consisting generally of "clay" or of "clay and sand." The formation where unweathered consists mainly of cavernous water-bearing limestones interbedded with water-bearing sands.

A small area along Ichawaynochaway Creek near Cordray Mill, in the northern part of the county, is underlain by strata of the Claiborne group and probably of the Jackson formation, both of which dip southward and pass beneath the Vicksburg formation. Beneath the Claiborne are several hundred feet of Eocene sands, clays, and marls, with thin interbedded layers of limestone or sandstone, belonging to the Wilcox or Midway formations or to both. Cretaceous sands and clays, which probably have an aggregate thickness of 2,000 feet or more, underlie the Eocene, and at an undetermined depth rest upon a basement of ancient crystalline rocks. Both the Eocene and Cretaceous will furnish large supplies of artesian water.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Over the greater part of the county water for domestic use is obtained from wells 15 to 60 feet deep. The waters of wells which reach the limestones are regarded by the people as unwholesome; but as no analyses of the waters are available the reason for their unsatisfactory character is not known. The shallow wells frequently fail during droughts. Small springs are numerous, but none of large size are known.

Artesian wells have been drilled at Arlington, Leary, Edison, Morgan, and on several plantations. Artesian water can probably be obtained anywhere in the county at depths of 300 to 1,500 feet or more, and the chances for obtaining flows are good on the lower land in the eastern part of the county. (See map, Pl. XVIII, p. 122.)

LOCAL SUPPLIES.

Arlington (population 1,308, census of 1910).—The principal source of water supply at Arlington is an artesian well (No. 2, Table 13) 1,173 feet deep, completed in 1909. The water is soft, clear, and slightly sulphurous, and has proved satisfactory for all purposes.

(See analysis 1, Table 14.) The principal water-bearing bed is at 640 feet and is said to be a porous white rock. The water rises to within 40 feet of the surface and the well yields 190 gallons of water per minute by pumping.

A well (No. 1, Table 13) used at Arlington prior to the one described is said to have been about 600 feet deep. Spencer [1] gives the following partial log:

Partial log of well at Arlington.

	Feet.
Chalky clay	20
Sand and white clay	(?)
Shell rock	5
Very coarse sand	(?)
Shell rock, etc	to 355
Hard rock, siliceous, with soft places	to 390
Hard dark clay	to 500 (?)
Coarse micaceous sand	to 540

The Arlington Oil & Fertilizer Co., at Arlington, owns a well 328 feet deep. Other deep wells in the town have not been reported upon in detail.

Leary (population 430, census of 1910).—The principal source of water supply at Leary is a public artesian well in the main part of the town, which flows 12 feet above the surface. It is described by McCallie as follows: [2]

> The Leary well is 2 inches in diameter and 672 deet deep. The water rises 30 feet above the surface. Two or more water-bearing strata are reported in this well above the one which furnishes the flow, but their depths are not given. The capacity of this well is said to be about 20 gallons per minute. The water is used for steam and general domestic purposes.
>
> The following (partial) record is given:

[*Log of town well at Leary.*]

	Feet.
Red clay	40
Limestone	20
Blue clay	100?
Hard rock	30
Quicksand	200?
Hard rock containing shells	10

Some shallow wells in the town, 15 to 60 feet deep, fail during droughts.

A fine flowing artesian well (No. 6, Table 13) on the Harper Daniel plantation, 4 miles south of Leary, is 778 feet deep and flows at the rate of 50 gallons per minute. Water-bearing beds were entered at 100, 250, and 650 feet. The water emits a strong odor of hydrogen sulphide and is moderately hard, in this respect differing from waters

[1] Spencer, J. W., Georgia Geol. Survey First Rept. Progress, p. 77, 1891.
[2] Georgia Geol. Survey Bull. 15, p. 72, 1908.

from about the same depths at Albany, Dougherty County (pp. 235–238); Newton, Baker County (p. 137); and Blakely, Early County (p. 245). An analysis of this water is given in Table 14 (analysis 3).

A well on J. E. Boyd's plantation, 3 miles north of Leary, is said to have been drilled to a depth of 400 feet without obtaining a flow.[1]

Edison (population 841, census of 1910).—The town of Edison owns a public water-supply system, which is supplied from an artesian well near the railroad, but about 10 feet lower than the track at the station. The well is 563 feet deep and yields, by pumping, 215 gallons of water per minute. The principal water-bearing bed is said to be a sand rock at 550 feet, probably belonging to the Ripley formation of the Cretaceous, from which the water rises to within 32 feet of the surface. An analysis of the water is given in Table 14 (analysis 2).

Morgan (population 302, census of 1910).—Both shallow and artesian wells are in use in the vicinity of Morgan. Part of the population obtains water from a private well owned by Williams & Tinsley, which probably taps a water-bearing bed in the upper part of the Ripley formation. The following information has been furnished by W. J. Ragan:

This well was completed in 1906; it is 600 feet deep, 6 inches in diameter, and flows 20 gallons per minute. The water will rise 8 feet above the surface.

Other wells similar to the Tinsley are those of T. J. Tinsley, a mile southwest of Morgan (No. 11, Table 13), of the Morgan Lumber Co., 1½ miles southwest of Morgan (No. 9, Table 13), of J. E. Boyd, 3 miles north of Leary (No. 7, Table 13), and of T. J. and T. W. Tinsley, 4 miles from Morgan (No. 12, Table 13).

Cordray Mill.—At Cordray Mill, on Ichawaynochaway Creek, 5 miles northeast of Morgan, are two flowing wells owned by W. H. Cobb, of Dawson. One on the bank of the creek near the mill is 361 feet deep and flows 12 gallons per minute. The water will rise 20 feet above the surface.

[1] Georgia Geol. Survey Bull. 15, p. 72, 1908.

TABLE 13.—*Wells in Calhoun County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Elevation above sea level or below datum.
						Feet.
1	Arlington	Town		J. W. Spencer[a]		+275
2	do	do	M. A. Jarrard	M. A. Jarrard	1909	
3	do	Arlington Oil & Fertilizer Co.		S. W. McCallie[b]		
4	Edison	Town	D. A. Sylvester	E. L. Smith	1910	c − 10
5	Leary	do		S. W. McCallie		+210
6	Leary (4 miles south of).	Harper Daniel	M. A. Jarrard	Harper Daniel and M. A. Jarrard.	1907	+175
7	Leary (3 miles north of).	J. E. Boyd				
8	Morgan					
9	Morgan (1½ miles southwest of).	Morgan Lumber Co.		W. J. Ragan	1909	+608
10	Morgan (in town limits).	Williams & Tinsley		do	1906	
11	Morgan (1 mile southwest of).	T. J. Tinsley		T. W. Tinsley		
12	Morgan (4 miles from)	T. J. and T. W. Tinsley.	N. M. Brewer	do	1908	
13	Morgan (5 miles northeast of).	W. H. Cobb		W. H. Cobb		
14	Williamsburg			W. J. Ragan		

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	600±	6			−20				
2	1,173	6	640	900	−40		190	Air compressor	Analysis 1, Table 14.
3	328	5	300						
4	563	6	550–563	475	−32		215	Air-lift pump	Analysis 2, Table 14.
5	672	2			+12	20		Flows	Hard.
6	778	2	650–778	100, 250		50		do	Analysis 3, Table 14.
7	400								
8	600				+30	25		Flows	
9	550	2			+ 7	20		do	Sulphurous.
10	600	6			+ 8	20		do	Do.
11	550		525			15		do	Soft.
12	452	4	430–440		+30	15		do	Do.
13	361				+20	12		do	
14					+ 5			do	

[a] Georgia Geol. Survey First Rept. Progress, p. 77, 1891.
[b] Georgia Geol. Survey Bull. 15, pp. 71–72, 1908.
[c] Datum is track at railroad station.

TABLE 16—*Wells in Calhoun County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	.....	Ripley formation?.	.....	See log, p. 172.
2	All purposes.....	.....do.....	Porous white rock.	8-inch casing to 240 feet; 6-inch casing to 360 feet.
3	.....	Eocene.....	.....	
4	Municipal supply.	Ripley formation?.	Sand rock.....	6-inch casing to 470 feet; cost of well, $3,000.
5	Domestic, boiler supply.	.....do.....	.....	See log, p. 172.
6	Domestic.....	.....do.....	Porous white rock.	4-inch casing to 100 feet; 2½-inch to 450 feet; 2-inch to 475 feet; cost of well, $1,756.
7	.....	.....	.....	
8	.....	.....	Rock.....	
9	Domestic.....	Ripley formation .	.....	Diameter at top, 6 inches; at bottom, 2 inches; cost of well, $1,500.
10	Boiler supply and domestic.	.....do.....	.....	Diameter at top, 6 inches; at bottom, 2 inches; cost of well, $2,000.
11	Domestic and manufacturing.	.....do.....	Gravel and sand...	4 inch casing to 525± feet; cost of well $1,250.
12	Domestic.....	Ripley formation?.	Rock and sand....	Cost of well, $1,000.
13	.....do.....	Wilcox formation?	.....	
14	.....	.....	.....	

TABLE 14.—*Analyses of underground waters from Calhoun County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	May 1, 1911	Town well.....	Arlington.....	Ripley formation..	640	Edgar Everhart.
2	May 5, 1911	.....do.....	Edison.....	Ripley formation?.	550–563	Do.
3	May 8, 1911	Well of Harper Daniel.	Leary (4 miles south of).	Ripley formation..	650–778	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Remarks.
1	25	0.4	10	3.0	57	10	150	12	0.1	10	233	No. 2, Table 13. Total depth of well, 1,173 feet.
2	17	.2	37	2.0	8.0	2.0	134	10	.1	4.0	162	No. 4, Table 13.
3	18	.6	44	5.0	17	7.0	190	8.0	.2	7.5	186	No. 6, Table 13.

CAMDEN COUNTY.

GENERAL FEATURES.

Camden County is on the Atlantic coast in the extreme southeastern part of the State. Its area is 711 square miles and its population 7,690 (census of 1910). It has no cities or large towns and no important manufacturing establishments. The production and shipment of lumber and naval stores and stock raising are its principal industries.

TOPOGRAPHY.

The eastern part of the county, a belt about 20 to 25 miles in width, is a low, sand-covered, marine terrace plain, in general less than 25 feet above sea level, which forms part of the Satilla coastal lowland (pp. 36–38). Along the coast and included in the Satilla coastal lowland are sand-covered islands which rise to a maximum of 20 feet above sea level, and which are separated by a network of tidal so-called creeks and rivers. There are also small areas of salt-water or brackish-water marsh. A narrow strip of level land in the western part of the county lies 25 to 30 feet above the first terrace plain and forms part of the Okefenokee plain (pp. 35–36). Nowhere in the county is the surface higher than 50 or 60 feet above sea level. Inland from the coast small streams are few in number and the surface is only slightly dissected; topographically it differs but little from its original condition. As a result of this lack of natural drainage there are large numbers of swampy flats or bays and small ponds which contain water throughout the year, except during times of unusual drought.

GEOLOGY.

Pleistocene sands and clays form the surface deposits over the greater part of the county. White or yellowish incoherent quartz sands cover the islands and the mainland near the coast, and a narrow sandy belt extends westward, fringing the swamp land of St. Marys and Satilla rivers. In the central and western parts of the county bluish or greenish muds or clays of Pleistocene age, in places containing oyster shells and calcareous nodules, locally underlie the flatwoods or savannah land. In most of the shallow driven wells the water is obtained from Pleistocene deposits, whose thickness probably does not exceed 50 feet. In places, beneath surficial sands, there are red or mottled argillaceous sands the age of which has not been determined but which probably belong to the Pleistocene.

Materials exposed at a few places on St. Marys River (Florida side) and on Satilla River have been referred to the Charlton formation (Pliocene?), but it may be doubted whether in descriptions of materials given in well logs the Charlton formation can be discriminated from the Miocene deposits. Strata of Miocene age underlie the county, but their thickness and their relations to other formations are unknown. They are believed to consist mainly of phosphatic sands and gravels with some soft sandy shell marls and some relatively thin clays. The thickness of the Miocene is inferred to be small because fossils probably indicating the Chattahoochee formation were obtained from a well at Tarboro between the depths of 350 and 400 feet, and because fossil Bryozoa and Nummulites, probably indicating the Vicksburg formation, were obtained in a well at Kings-

land between the depths of 450 and 482 feet. If these correlations are correct whatever representatives there are of the Alum Bluff formation and of the Miocene, Pliocene, and Pleistocene must all be included in a thickness not exceeding 350 feet. Little is known of the character of the deposits at depths greater than 500 feet. The basement crystalline rocks probably lie at a depth of 3,000 to 4,000 feet.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The domestic water supply is obtained principally from artesian wells and from shallow driven wells. There are a few small springs, but as sources of supply these are of little importance, even locally.

Thirty-six flowing wells have been reported from the county—one or more from every town or village at which there is a post office. They furnish an abundance of clear, wholesome water. The underground waters are also used in the locomotive boilers and sawmill plants. The principal objection to the artesian waters is that they are slightly hard and emit a rather disagreeable odor of hydrogen sulphide. The wells range in depth from 200 to 500 feet and furnish flows at elevations of 10 to 50 feet above the surface; they are put down at costs ranging from $250 to $800. So far as data have been obtained there has been no decrease in the supply which could be attributed to an overdrain on the artesian reservoirs. (See Table 15.)

The shallow wells, 10 to 20 feet deep, driven or dug, furnish soft nonartesian waters which, however, are not so wholesome as artesian waters. Driven or bored wells are preferable to dug wells, because in them the water is protected by the pipe or casing from pollution.

The prospects are good for obtaining flowing artesian wells throughout the county.

LOCAL SUPPLIES.

St. Marys (population 691, census of 1910).—Two artesian wells at St. Marys supply water for domestic use and for all other purposes. McCallie [1] gives the following account of the public well

> The deep well at St. Marys, the county seat, is 4 inches in diameter and has a depth of 522 feet. The water-bearing strata occur in this well one at 300 feet and the other at 500 feet. The present water supply is obtained from the lower stratum, the upper stratum being cased off. The water from the former stratum rises 50 feet above the surface, or about 40 feet above high tide. The water is rather heavily charged with hydrogen sulphide and forms a white precipitate about the overflow pipes.

A mineral analysis of the water from this well is given in Table 16 (analysis 2).

[1] Georgia Geol. Survey Bull. 15, p. 67, 1908.

Kingsland (population 190, census of 1910).—Four or more artesian wells at and near Kingsland supply an abundance of wholesome water. Open dug wells, 10 to 15 feet deep, are also used.

The deepest artesian well, 647 feet deep, is about 250 yards north of the railroad station and is owned by the Camden Naval Stores Co., the water being used chiefly for drinking and for condensing in the distillation of turpentine. H. C. Russell, the well contractor, has supplied information relating to the depth and character of the water-bearing strata. The first flow, which was found at 285 feet in a shell bed 6 feet thick, was 3 gallons per minute 4 feet above the surface. A second flow was encountered at 470 feet, the static head of which was 28 feet above the surface. The well was continued to 647 feet, and although the yield increased to 80 gallons per minute there was no increase in the pressure. The material from depths of 470 to 647 feet is fossiliferous or shell-bearing limestone with alternating hard and soft layers. (See analysis 1, Table 16.)

From another well recently completed at Kingsland borings taken between the depths of 450 and 482 feet contained fossils, chiefly Bryozoa and Nummulites, which according to T. W. Vaughan are of Vicksburg age.

Tarboro.—Tarboro, a small village 5 miles southwest of Whiteoak station, has four artesian wells which furnish strong flows. (See Nos. 16–18, Table 15.) The combined flow of three of them is utilized in operating a small rice and lumber mill. (See Pl. XIX, *B*, p. 152.) Flows are obtained from two beds, one at about 160 feet and the other between 350 and 400 feet. (See analysis 3, Table 16.) Fossils obtained from one of the wells between the depths of 375 and 400 feet were submitted to T. W. Vaughan, who considers the stratum from which they were taken as probably referable to the Chattahoochee formation.

TABLE 15.—*Wells in Camden County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Baileys Mill (near)	L. M. Bedell		S. W. McCallie[a]	1895	
2	Ceylon	Hilton & Dodge Lumber Co.		E. P. Noyes	1895?	
3	Cumberland Island	Hotel Cumberland		L. A. Miller	1889?	6
4	Cumberland Island (Dungeness, near the southern end of the island).	Mrs. Lucy Carnegie.		O. H. Wade and S. W. McCallie.[a]		
5	Kingsland	W. N. Casey	Mr. Clay	U. L. Stafford	1895	40?
6	do					
7	do	Camden Naval Stores Co.		H. C. Russell	1910	41
8	Lang (near)					
9	Midriver (near)					

[a] Georgia Geol. Survey bull. 16, pp. 67–71, 1908.

TABLE 15.—*Wells in Camden County*—Continued.

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
10	Owens Ferry	Dyal & Lang		S. W. McCallie [a]	1903	20?
11	Pearl (4 miles west of)	Davis & Brandon	Dave Stafford	H. W. Mobley		
12	Satilla Bluff	Hilton & Dodge Lumber Co.		S. W. McCallie [a]		20
13	....do	J. F. Foster				20
14	Silco					
15	St. Marys	Town	H. C. Russell	S. W. McCallie [a] and J. S. Russell.		16
16	Tarboro	Stafford Bros.		S. W. McCallie [a]		
17	....do	J. B. Godley		....do	1902	
18	....do	W. C. Lang				
19	Tarboro (1½ miles northeast of).	J. S. Bruce				
20	Tompkins					
21	Waverly (1 mile south of).	Dr. B. Atkinson	Dave Stafford	Postmaster	1902?	
22	Waverly (2½ miles north of).	Georgia Land Co.				
23	Waverly (4 miles west of).	Dr. B. Atkinson				
24	Waverly (600 feet northeast of).	T. G. Middleton & Co.		H. R. Lang	1911	
25	Waverly (90 feet north of post office).	McKinnin & McCarthy.		....do	1911	
26	Whiteoak	L. T. McKinnon		S. W. McCallie [a]	1894	5
27	....do	Mr. Baker			1908?	5
28	Woodbine	Seaboard Air Line Ry.	H. C. Russell	H. C. Russell	1909	22

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Height of water above surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	200	2						Flows	
2	365	2	365		32				Hard, sulphurous.
3	750	3		400–500	20				Hard.
4	680	6		400	51				
5	500	2	350–500		25	500			Sulphurous.
6	75							Slight flow	
7	647	3	470–647	285	28	80		Flows	Analysis 1, Table 16.
8									
9									
10	370	2			25				Slightly sulphurous.
11	465	6	465	300	35	60			Sulphurous.
12	340	2	340	60, 210				Flows	Slightly sulphurous.
13	350	2	350	250				....do	Do.
14									
15	522	4	500	300	40				Sulphurous. Analysis 2, Table 16.
16	375	8	375	175	50				Slightly sulphurous. Analysis 3, Table 16.
17	350	2	350	200	40				Hard, sulphurous.
18	345	2		250, 300	50				
19	414	2		150	50				Do.
20									
21	350	2			10			Flows	Soft, sulphurous.
22	250?	2			6–8				
23	250?							Flows	
24	490	2			5				Soft.
25	490	2			5				Do.
26	450	4	450	130	50				Hard, sulphurous.
27	365							Flows	Sulphurous.
28	444	4	436–444	228–332	50				Do.

[a] Georgia Geol. Survey Bull. 15, pp. 67–71, 1908.

TABLE 15.—*Wells in Camden County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Miocene or Oligocene.		
2	Boiler supply, domestic.	Chattahoochee formation?	Gravel	Elevation 15 feet above Satilla River. Cost of well, $250.
3	Domestic	Tertiary		
4		do		Three other flowing wells, 400 to 700 feet deep, on island.
5	Domestic, boiler supply for locomotives.	Vicksburg formation?		2-inch casing, 350 feet. Cost of well, $300.
6		Tertiary		
7	Domestic, manufacturing.	do	Bed of shells	Cost of well, $400.
8				One flowing well.
9				Do.
10	Domestic, irrigation.	Chattahoochee formation?		One other well, no information.
11	Domestic, manufacturing.	Vicksburg formation?	Rock	Cost of well, $300.
12		Chattahoochee formation?		
13		do		
14				One well, no information.
15	Domestic, boiler supply.	Vicksburg formation?		Cost of well, $800.
16	Domestic	Chattahoochee formation?		Three wells, 8 inches in diameter; one well, 1 inch.
17	do	do	Porous limestone at bottom.	
18	do	do		Limestone at 100 feet and between 200 and 300 feet.
19	do	do		Cavernous limestone at 414 feet.
20				Three flowing wells.
21	Domestic, boiler supply for locomotives.	Chattahoochee formation.		
22				
23	Stock			
24		Vicksburg formation?	Sand	
25		do		
26	Domestic	do		Limestone at 200 feet.
27	do	Chattahoochee formation?		
28		Vicksburg formation?	Bed of shells	Cost of well, $400; 4-inch casing to 188 feet.

TABLE 16.—*Analyses of underground waters from Camden County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	June 7, 1911	Well of Camden Naval Stores Co.	Kingsland	Tertiary	470–647	Edgar Everhart.
2	May 6, 1911	Town well	St. Marys	Vicksburg formation?	500–522	Do.
3	Apr. 14, 1911	Well of Stafford Bros.	Tarboro	Chattahoochee formation?	350–375	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	41	2.0	74	35	23	0.0	229	131	.....	26	.....	484	No. 7, Table 15.
2	43	.4	73	8.0	60	.0	152	170	Tr.	33	.....	504	No. 15, Table 15.
3	36	.4	45	26	17	.0	178	92	1.5	14	.....	323	No. 16, Table 15.

CHARLTON COUNTY.

GENERAL FEATURES.

Charlton County is in southeastern Georgia and borders Florida. It has an area of 905 square miles and a population of 4,722 (census of 1910). The county is thinly settled and contains no large towns. Lumbering, turpentine distilling, and stock raising are the principal industries.

TOPOGRAPHY.

The eastern part of the country is a flat sand-covered plain; the western part is covered by the Okefenokee Swamp and is practically uninhabited. St. Marys and Satilla rivers have cut relatively deep courses and are bordered by flat terrace plains about 15 feet above the river levels; both are sluggish and are affected by the tide, the St. Marys to a few miles above Traders Hill and the Satilla to a few miles above Burnt Fort. Although the main streams have cut down almost to grade, the tributary streams, which are few in number, have effected but little erosion and topographically the surface is youthful. Small ponds and swamps are common. The known elevations above sea level are Folkston, 80; Racepond, 148 (probably the highest point in the county); Wainwright, 83; St. George, 78; and Moniac, 114.

GEOLOGY.

Loose white and yellow quartz sands, probably nowhere exceeding 20 feet in thickness, form the surface over the entire county. These sands are very porous and absorb the rainfall readily. They are underlain by 50 feet or less of red and white sands containing thin bluish clay layers, the age of which is not certainly known but which is believed to be Pleistocene. The surface sands and the underlying red and white sands furnish the water of the shallow wells. The red and white sands are underlain by the Charlton formation (probably Pliocene), which consists of clays, limestones, and marls that are exposed on St. Marys River from near Stokes Ferry downstream to Orange Bluff, 2 miles above Kings Ferry, Ga., and on Satilla River at Burnt Fort, on land of W. M. Thrift, 6 miles east of Winokur and on the King plantation, 6 miles south of Atkinson. The Charlton formation probably underlies a small area in the eastern part of the county. Beneath the Charlton are strata of probable Miocene age, and beneath the Miocene are 100 feet or more of sands and clays belonging to the Alum Bluff formation (Oligocene). Undifferentiated limestones, sands, clays, and marls, which belong in descending order to the Eocene and Cretaceous, underlie the Alum Bluff formation. At an undetermined depth, probably 3,000 feet or more, the Cretaceous deposits are believed to rest upon a basement

of ancient crystalline rocks. Water-bearing beds may be expected in both the Alum Bluff formation and the underlying undifferentiated Eocene or Cretaceous deposits.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Water supplies in the county are obtained chiefly from driven or dug wells, commonly 10 to 20 feet deep, which can be put down at little expense and which furnish abundant supplies of soft water. In many of the open dug wells the water stands within 2 or 3 feet of the surface and may be polluted. Driven wells, made by driving a small iron tube with a strainer point down to the water-bearing bed are, for hygienic reasons, preferable to dug wells. There are a few unimportant small seepage springs. The waters of the ponds and streams are stained dark brown to black by vegetable matter.

Wholesome water can be obtained from deep wells at any place in the county. Wells 200 feet or more in depth, located in the valleys, on land 70 feet or less above sea level, will flow at the surface.

LOCAL SUPPLIES.

Folkston (population 355, census of 1910).—Folkston, the county seat and the largest town in the county, is not equipped with a water-supply system but owns a deep well (No. 2, Table 17), from which many of the inhabitants obtain supplies for domestic purposes. This well, which was completed in 1908, is 612 feet deep and 3 inches in diameter. The principal water-bearing bed is reported to be at 510 feet, and the water, which rises to within 12 feet of the surface, is not lowered by pumping. The water is slightly hard but is suitable for general domestic purposes.

Burnt Fort.—At Burnt Fort, a small community on the terrace bordering Satilla River, 12 miles northeast of Folkston, a well (No. 1, Table 17) owned by Mr. L. M. Bedell is 200 feet deep and furnishes a strong flow of sulphurous water.

TABLE 17.—*Wells in Charlton County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Burnt Fort, 12 miles northeast of Folkston.	L. M. Bedell				
2	Folkston	Town	H. C. Russell	W. M. Olliff	1908	80
3	St. George			Postmaster		

TABLE 17.—*Wells in Charlton County*—Continued.

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Level of water below surface.	How obtained.	Quality.	Use.	Geologic horizon of principal water bed.
	Feet.	*Inches.*	*Feet.*	*Feet.*				
1	200	.....	.....	.....	Flows...	Sulphurous.....	.....	Alum Bluff formation?
2	612	3	510	12	.....	Slightly hard.....	Domestic.....	Vicksburg formation?
3	65	.....	45	.....	Pumps..	Sulphurous, hard .	.....	Charlton formation?

CHATHAM COUNTY.

GENERAL FEATURES.

Chatham County is on the seacoast in the eastern section of the Coastal Plain of Georgia. Its area is 370 square miles, and its population (census of 1910) is 79,690, of which 65,064 live in Savannah. Savannah is an important seaport, exporting chiefly naval stores, raw cotton, and lumber. It contains fertilizer factories, cottonseed-oil mills, cotton cloth mills, ice factories, a brewery, car works, machine shops, a canning factory, and many small plants.

TOPOGRAPHY.

The lands adjacent to the coast are low and the coast line is irregular. The eastern part of the county contains many low, sand-covered islands separated by sounds, tortuous brackish and salt water creeks and rivers. On the islands and adjacent mainland there are small areas of marsh land. The western part is a flat poorly drained plain, on which low sand hills or sand ridges, bays, and low moist areas are underlain by clay and silt of marine or brackish water origin. The low flat areas are probably the sites of former tidal arms of the ocean.

Savannah River forms the eastern boundary of the county and Ogeechee River the western boundary. The water of the Savannah is always more or less turbid and yellowish from suspended silt and clay carried down in suspension from the Piedmont Plateau. Ogeechee River is rarely muddy, and although its headwater streams are in the southeastern part of the Piedmont Plateau the water has the aspect of the streams which originate in the Coastal Plain. Adjacent to the mouths of both the Savannah and the Ogeechee are salt-water marshes and tidal-swamp lands (see pp. 36–37), which extend several miles above the salt marshes. The only other important stream in the county is Little Ogeechee River which has its source in the Coastal Plain and flows southeastward through the western part of the county. Its water is dark or amber-colored from organic matter, but it carries only a small amount of silt or clay in suspension. On

account of the youth of the land surface and its low elevation stream erosion has been a minor factor in the formation of the topography.

The surface of the greater part of the county lies between 15 and 25 feet above sea level, but there are a few places in the northern part of the county which probably reach a maximum of 50 or 60 feet.

GEOLOGY.

The greater part of the county is covered by late Pleistocene deposits, belonging to the Satilla formation, which consist of loose, fine, quartz sands rather uniformly distributed, though in places heaped into hills by wind or wave action, and of sandy muds or clays containing organic matter deposited in the swampy flats. The Pleistocene deposits probably do not exceed 25 or 30 feet in thickness, but they are the source of the water obtained in shallow dug and driven wells. Beneath the surficial Pleistocene sands, at a few localities, are red or yellowish sands containing thin bluish clay laminæ, which are older than the Satilla formation and probably belong to an older Pleistocene formation. These red and yellow sands are thin and have no important bearing on the water supplies. At Savannah, beneath the Pleistocene deposits and the red and yellow sands of questionable age, the strata, to a depth of about 250 feet, consist of fine more or less argillaceous sands, bluish or greenish sandy clays, soft shell marls, and limestones which are of Tertiary age and are probably younger than the Chattahoochee formation (Oligocene), but which have not been differentiated into formations. Locally, these beds are water bearing and supply wells 270 feet or less in depth. Porous, sandy limestones, which may represent in descending order the Chattahoochee, Vicksburg, and Jackson formations, are encountered at Savannah between 250 and 500 feet. These limestones are an important source of artesian supplies in this and adjoining counties.

Little is known concerning the character and age of the Coastal Plain deposits existing beneath the limestones, but it is perhaps reasonable to assume that the Claiborne group (Eocene) and the Upper and Lower Cretaceous sands and clays are represented. Beneath the Lower Cretaceous deposits, perhaps at some depth between 2,500 and 4,000 feet, are the crystalline basement rocks. The Eocene and Cretaceous deposits doubtless contain water-bearing beds, some of which would yield potable waters.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Artesian wells are the chief source of water supply in the county. The city of Savannah, the second largest city in the State, derives its supply from artesian wells. Many private wells have been sunk in the city and throughout the county.

Shallow dug and driven wells 6 to 25 feet deep furnish soft but not always wholesome water. Water from driven wells is safer than that from dug wells.

Water from Savannah River is used in boilers at many factories at Savannah. Elsewhere in the county surface waters are not used extensively.

Springs are few in number, small, and usually unwholesome.

Artesian waters may be obtained throughout the county at depths ranging from 50 to 1,500 feet or more. Most wells, especially those exceeding 100 feet in depth, will flow.

LOCAL SUPPLIES.

Savannah (population 65,064, census of 1910).—The municipal water supply at Savannah is derived from 13 artesian wells (No. 5, Table 18) in the western part of the city. One well is 1,550 feet deep and the others are from 475 to over 500 feet (the average depth is said to be 500 feet). Originally they all flowed, but later the yield decreased to such an extent that it became necessary to pump them; in 1910 the consumption from the 13 wells was 9,500,000 gallons a day. A description of the water-supply system and an explanation of the decreased yield of the wells has been given by C. S. Slichter,[1] the greater part of whose paper is here quoted. Table 19 gives a mineral analysis of the water of the present supply (analysis 1) and an analysis of water from the wells at the old city waterworks (analysis 2).

> One of the most carefully planned artesian water supplies of this country is that of the city of Savannah, Ga. A brief account of these wells is of much interest, not only as illustrative of an intelligently designed and well-constructed engineering work, but also because of the valuable lessons to be learned from the way in which difficulties were met and overcome as they arose. The works were planned by Mr. Thomas T. Johnston, consulting engineer, of Chicago, Ill., and the following description is taken largely from his paper in Engineering News.[2]
>
> Prior to 1887 the water supply of Savannah was taken from the river, but in that year 14 artesian wells were put in use (a fifteenth well being nearly ready) near the old pumping station. Of these wells 2 were 10-inch, 12 were 6-inch, and 1 was 4-inch, and not one was more than 400 feet deep. In 1888 the entire supply of the city was drawn from these wells, the total for the year being 2,135,842,000 gallons, or about 5,850,000 gallons per day. At the close of 1889, 5 new wells had been put in use, the 20 wells being distributed very irregularly within a 10-acre lot. About this time, however, it became necessary to open the river supply to some extent. Experience and observation showed conclusively that the water supply was materially affected by the tide, and it

[1] U. S. Geol. Survey Water-Supply Paper 67, pp. 97-101, 1902. [2] Eng. News, vol. 29, pp. 527-529, 1893.

was supposed that the shallowness of the wells caused a filling by sand to a greater or less extent, thus affecting the supply. But little better results were had, however, from deepening some of the wells, one of them being deepened to 1,009 feet. Two additional 10-inch wells 502 and 505 feet deep were connected with the old works on December 29, 1890, but in November, 1891, it was necessary to again draw water from the river. Nothing resulted from dynamiting the wells. [Wells No. 4, Table 18.]

In June, 1891, it was found that water in well No. 1, close to the old pumping station, was 9 feet lower than in well No. 2, distant from well No. 1 about 1,600 feet, and it was determined to abandon the old wells.

Twelve new wells in a new location were finally decided upon, and 7 were put in use on December 9, 1892, and the others on March 21, 1893. * * * [No. 5, Table 18.] The wells are arranged along a highway which runs nearly parallel to the ocean and some distance from the old pumping station. They are 300 feet apart and flow into a brick and concrete conduit. * * * Sands and clays were met to a depth of about 250 feet, where a cherty lime rock was found. The rock varies in character at greater depths. The first water was found at 325 feet, and the supply continually increased until the depth exceeded 500 feet. The water-bearing rock is uniformly a porous limestone, or rather one full of cavities, very similar to the rock outcrop from which flow the mammoth Suwanee springs in northern Florida. Water is occasionally found below 500 feet, but not in sufficient quantity to justify deeper wells. The 12 wells of the new waterworks average 500 feet in depth. They are cased to the rock (about 250 feet) with casing of 12 inches internal diameter. Below this there is a 12-inch clear opening. The normal position of water in the wells, as determined by the position in the old wells when first dug, showed that it reached the static level at an elevation of 41 feet above mean low tide. Subsequent wells, bored in a wide range of country, show about the same elevation. After a number of wells had been bored the elevation of this static level was lowered. At the time of an examination in 1890 about 6,000,000 gallons per day were being pumped at the old works. The static level was then 7 feet; at the site of the new works it was at an elevation of 28 feet, while 9 miles south of the old works it was at the original elevation, 41 feet. The influence of the heavy pumpage was noticed to be greater in wells in the same line perpendicular to the shore of the ocean than in wells in a line parallel to the ocean. To predetermine the probable flow from the new wells, the Springfield well, 2,000 feet east of the new station, was examined, with the following results:[1]

Flow of Springfield well, Savannah.

Elevation of static level above mean low tide.	Equivalent head.	Flow.	Year.
Feet.	*Feet.*	*Galls. per 24 hours.*	
27.67	0	.....	1890
25.67	2.00	482,000	1890
24.40	3.27	623,000	1891
22.77	4.90	1,000,000	1890
22.68	4.99	977,000	1891
21.80	5.87	1,133,000	1891
21.79	5.88	1,172,000	1891
20.57	7.10	1,360,000	1890
13.00	14.67	2,500,000	1890

It was estimated that about 3,000,000 gallons per day could be obtained with the static head reduced to an elevation of 7 feet, which reduction is practicable at the pump house, as constructed. The old wells spread over an area about 1,700 feet

[1] A section of this well is shown in Eng. News, vol. 30, p. 4, 1893.

wide at its largest part, and their flow at an elevation of 7 feet was about 6,000,000 gallons per day.

The first seven wells embraced a line 1,800 feet long. Reducing the level to 8 feet, the flow was 6,500,000 gallons per day. The level in wells Nos. 10, 11, and 12 was at this time 14.93, 15.96, and 16.20 feet, respectively. On March 21, 1893, the 12 wells were put into service, with elevation of water at 8 feet, and the flow was 9,500,000 gallons per day. At the beginning of 1897 the flow of the 12 wells had decreased to 6,900,000 gallons per day, and the fear was entertained that the history of the old plant was to be repeated. Mr. Johnston was again called in consultation. The results of his measurements of the flow of each of the 12 wells were as follows:

Yield of Savannah wells in 1897.

Well.	Flow.	Well.	Flow.
	Galls. per 24 hours.		*Galls. per 24 hours.*
No. 1	713,460	No. 9	399,740
No. 2	460,460	No. 10	468,050
No. 3	543,950	No. 11	371,910
No. 4	361,790	No. 12	485,760
No. 5	485,760		5,490,100
No. 6	293,480	Springfield well	1,019,590
No. 7	452,870		
No. 8	452,870		

From this table it is seen that wells Nos. 4, 6, and 11 showed a very small flow, entirely out of proportion to that of the other wells.

It having been determined that the flow of water in some wells was more obstructed than in others, the work of attempting to remove the obstructions was undertaken. The method used was back flushing, or the forcing of a strong reverse flow back into the well. The first effort was made on well No. 2 by means of fire hose attached to a neighboring hydrant. Only a slight improvement resulted. The next attempt was made on well No. 10, fire engine No. 2 being used. But little improvement resulted. A more powerful fire engine (No. 3) was next employed, and the process was tried on well No. 6. A radical improvement was the result, the net gain in the yield of the well being 100,000 gallons per day. Encouraged by this result, the next effort was made on well No. 4, fire engines Nos. 1 and 3 being used. The result was even more radical, the net gain in yield for this well being 200,000 gallons per day.[1] The actual results on well No. 6 were as follows:

Results of flushing well No. 6, Savannah waterworks, in 1897.

	Gallons per 24 hours.
Flow before flushing:	
May 12	295,000
May 18	304,000
Flow after flushing:	
May 18	433,000
May 19	395,000
May 20	400,000
May 24	389,620

After these experiments Mr. Johnston recommended that a special 8-inch water main of the city system be laid along the row of 12 wells, and that it be connected to each well by means of a 6-inch pipe and gate. By opening a gate any well can now be flushed at any time, and Superintendent Kinsey of the waterworks states that all of the wells have been flushed and tested regularly every year since Mr. Johnston's tests in 1897. The following is the record of the test for the year 1900:

[1] Report of T. T. Johnston to chairman of water commission, Savannah, Ga., May 24, 1897.

Results of flushing Savannah wells in 1900.

	Gallons per 24 hours.
Yield before flushing	5,104,275
Yield after flushing	5,850,878
Gain	746,603

The yield before flushing given above is 385,825 gallons less than the total yield before flushing in 1897.

The results at Savannah are especially valuable on account of their reliability and the fullness of the information. In the first place, the yield of the wells can be closely relied upon, for they were determined by a special current meter designed by Mr. Johnston, which can at any time readily be lowered into one of the wells. In the second place, it was found by actual measurements at the old waterworks that there had been no lowering of the water table during the years 1892 to 1897, as the measurements made in the two years were in substantial accord. Thus the depreciation of the wells must be referred to the clogging of the pores in the rock in some unknown way, and not to a general depreciation of the basin.

The following description of the strata penetrated in the city wells at Savannah in the first 510 feet of depth has been prepared by McCallie:[1]

Section descriptive of strata penetrated in city wells at Savannah.

	Thickness.	Depth.
	Feet.	*Feet.*
Fine sandy clay with a few fragments of fossiliferous limestone, more or less rounded by water	30	30
Dark grayish-green marl containing rounded pebbles and fragments of oyster shells and a few grains of glauconite	40	70
Very tough dark-colored clays with quartz pebbles and glauconite	10	80
Brownish clay containing dental plates of rays and minute rhombohedrons of calcite	10	90
Greenish-gray clay, containing fragments of shells and sharks' teeth	10	100
Same; also contains dental plates of rays	20	120
Greenish-gray clay, frequently indurated	40	160
Gray marl with round pebbles and glauconite. Microscopic examination shows the marl to consist largely of rhombohedral crystals of calcite	20	180
Greenish-gray marl, containing water-worn pebbles of feldspar and quartz. Calcite crystals are also abundant	30	210
Dark-gray clay with a few water-worn pebbles	20	230
Dark-gray marl, containing fragments of corals, sea urchins, etc	60	290
White, porous, concretionary, fossiliferous limestone, Foraminifera, fragments of oyster shells, and spines of sea urchins	30	320
More or less compact gray limestone, containing fossils similar to those of the overlying beds; also a few remains of gastropods	10	330
White concretionary limestone with fossils similar to the above	70	400
Gray marl, in places hardened into a porous rock containing fragments of oysters, pectens, crinoid stems, Foraminifera, and small crystals of calcite	10	410
Same; except that it contains fewer crinoid stems	3	413
Very white, chalky limestone, made up largely of corals	27	440
Gray coralline limestone, containing glauconite and many crinoid stems	10	450
Same; glauconite abundant	25	475
Dark greenish-gray marl, with glauconite filling casts of corals and Foraminifera; also fragments of compact coralline limestone which probably formed thin layers in the marl	35	510

The log of a well (No. 6, Table 18) completed in 1905, owned by the Mutual Fertilizer Co., 3 miles west of the post-office building at Savannah, is given by Fuller and Sanford[2] as follows, on the authority of the Hughes Specialty Well Drilling Co., contractors:

[1] Georgia Geol. Survey Bull. 15, pp. 75, 76, 1908.

[2] U. S. Geol. Survey Bull. 298, p. 199, 1906.

Log of well of Mutual Fertilizer Co., 3 miles west of post-office building at Savannah (No. 6, Table 18).

	Thickness.	Depth.
	Feet.	*Feet.*
Soft dark-brown soil	1	1
Soft light-gray sand	2	3
Red and gray clay and fine sand	17	20
Loose dark-gray sand	10	30
Hard greenish-gray sandy limestone	1.5	31.5
Tough dark-green sandy marl	203.5	235
Porous white limestone, slightly sandy; water bearing	10	245
Soft gray porous limestone	25	270
Coarser-textured white, brownish, and gray limestone with coarse sand, bits of shells, and dark grains, the latter probably phosphatic; contains Orbitoides (?) identified by Dr. Joseph A. Cushman; water bearing	40	310
Light-buff limestone; considerable water	20	330

According to the authority cited, the diameter of this well is 8 inches, the length of the casing is 136 feet, and the water is hard and rises to within 4 feet of the surface. A partial set of well borings from the well is on file in the office of the United States Geological Survey (well No. 380). From materials in this set representing depths between 270 and 290 feet were obtained remains of Bryozoa which, according to R. S. Bassler, are related to the Bryozoan fauna from the Eocene limestone of uppermost Jackson age at Wilmington, N. C., but which may indicate the Vicksburg rather than the Jackson age of the formation.

Tybee Island.—On Tybee Island there are about 20 artesian wells, which range in depth from 80 to 240 feet. The waters are derived from strata of Tertiary age and appear to be similar in their mineral character to the waters obtained from wells at Savannah. They are used for general domestic purposes, for the manufacture of ice, and in boilers of locomotives of the Central of Georgia Railway. Most of the wells flow at the surface, but the static heads are affected by the tide, some of them ceasing to flow at low tide.

A well at the cottage of W. J. Floyd, near Inlet station, is about 160 feet deep, and is cased to a depth of 84 feet, at which depth a layer of hard rock was encountered. It flows continuously 3 feet above the surface and does not appear to be materially affected in its yield by the tide. (See analysis 3, Table 19.)

Pooler (population 337, census of 1910).—Pooler derives its water supply in part from an artesian well (No. 3, Table 18) owned by S. H. Oliver, and in part from shallow wells 16 to 40 feet deep. Mr. Oliver's well was drilled in 1890 to a depth of 450 feet with a diameter of 3 inches. The water is reported to be derived principally from limestone at 450 feet. At present the water will rise 10 feet above the surface, but since the completion of the well the flow has decreased, owing perhaps to a clogging of the pore spaces in the

water-bearing bed or to a clogging of the well casing by bacterial vegetable growth. The original rate of flow could probably be partly restored by shooting the well, or by backflushing it in the manner employed at Savannah (pp. 187–188).

Montgomery.—H. D. Weed, of Savannah, reports that five artesian flowing wells on a sea island 10 to 16 miles south of Montgomery are 285 to 400 feet deep and 2 to 8 inches in diameter (No. 2, Table 18). In these wells the water rises 10 to 15 feet above the surface. The principal water-bearing bed is porous limestone at 280 feet. The water is sulphurous and is used for general domestic purposes and for irrigation.

Burroughs.—An artesian well at Burroughs (No. 1, Table 18) owned by H. A. Fountain is 315 feet deep and flows 20 feet above the surface. The water is used for domestic purposes. Two other flowing wells are owned, one by the Atlantic Coast Line Railroad and the other by the Seaboard Air Line Railway.

TABLE 18.—*Wells in Chatham County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Burroughs	H. A. Fountain, Savannah, Ga.	Mr. Corey	H. A. Fountain	1905	19
2	Montgomery, 10 to 16 miles south of, on a sea island.		Edward Corey, Keller, Ga.	Henry D. Weed		10
3	Pooler	S. H. Oliver			1890	
4	Savannah	City		Thomas T. Johnston,[a] C. S. Slichter,[b] S. W. McCallie.[c]		10.25–18.62
5	do	do		do		11.30–20.82
6	Savannah (3 miles west of).	Mutual Fertilizer Co.	Hughes Specialty Well Drilling Co., Charleston, S. C.	Driller and owner.	1905	
7	Tybee Island					
8	do	Tybee Ice, Water & Irrigation Co.		S. W. McCallie[c]		13
9	do	U. S. Government, Fort Screven Reservation.		do		
10	do	do		do	1902	

[a] Eng. News, vol. 29, pp. 527–529, 1893.
[b] U. S. Geol. Survey Water-Supply Paper 67, pp. 97–101, 1902.
[c] Georgia Geol. Survey Bull. 15, pp. 72–81, 1908.

TABLE 18.—*Wells in Chatham County*—Continued.

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	315	2	.....	.....	+ 20	.....	.....	Flows.....	Sulphurous.
2	285–400	2–8	280	.....	+10–15	30–500	.....	.....do.....	Do.
3	450	3	450	.....	+ 10	.....	.....	.....do.....	
4	380–500	4–10	.....	.....	(a)	.....	.....	.....	Analysis 2, Table 19
5	475–1,550	12	.....	.....	(a)	.....	.....	.....	Analysis 1, Table 19.
6	330	8	.....	.....	− 4	.....	.....	.....	Hard.
7	80–240	.....	.....	.....	.....	.....	.....	.....	
8	158	3	.....	.....	.....	.....	.....	Flows.....	
9	80	1	.....	.....	.....	10–30	.....	.....do.....	
10	156	6	.....	.....	.....	.....	.....	.....do.....	

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic.....	Tertiary.....	Clay and sand.....	Cost of well, $115.
2	Domestic and irrigation.	.....do.....	.....	
3	.....	Vicksburg formation?	Limestone.....	
4	Domestic.....	.....do.....	Cavernous limestone.	Old waterworks; 22 wells, nine 10-inch, twelve 6-inch, one 4-inch.
5	.....do.....	Vicksburg formation?[b]	.....do.....	New waterworks; 12 wells 475 to 500+ feet deep and 1 well 1,550 feet deep; 12-inch casing to 250 feet.
6	Manufacturing....	Vicksburg formation?	Limestone.....	8-inch casing extends to a depth of 136 feet.
7	Domestic and manufacturing.	Tertiary.....	.....	Many wells.
8	Boiler supply, irrigation, domestic.	.....do.....	.....	
9	.....	.....	.....	
10	.....	Tertiary.....	.....	

[a] Original static head 41 feet above mean low tide.
[b] The 1,550-foot well probably taps the Cretaceous.

TABLE 19.—*Analyses of underground waters from Chatham County.*

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	Apr. 11, 1911	Municipal supply from 12 wells 475 to 500+ feet deep and 1 well 1,550 feet deep.	Savannah.....	The wells 475 to 500+ feet, Vicksburg formation?; the 1,550-foot well, Cretaceous?	475–500+ and 1,500	Edgar Everhart.
2	1886	Deep wells formerly municipal supply.	.....do.....	Vicksburg formation?	500±	C. F. Chandler.[a]
3	Apr. 11, 1911	Well of W. J. Floyd	Tybee Island near Inlet station.	Tertiary.....	160±	Edgar Everhart.
4	1886	Artesian well.....	Tybee Island.....	.....do.....	240±	C. F. Chandler.[b]
5	1885	.....do.....	.....do.....	.....do.....	240±	H. C. White.[b]

[a] Georgia Geol. Survey Bull. 15, pp. 73, 74, 1908. [b] Idem, pp. 77–79.

TABLE 19.—*Analyses of underground waters from Chatham County*—Continued.

[Parts per million.]

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	58	1.0	26	10	17		2.0	170	8.0	0.4	7.0	.....	220	Wells No. 5, Table 18.
2	55	a.4	25	7.2	10	1.7	.....	.....	11	2.2	11	9.9	229	Trace of PO_4. Wells No. 4, Table 18.
3	35	.6	23	12	17		.0	159	12	9.0	8.0	.....	202	
4	60	a.4	22	10	17	2.6	.....	39	12	.....	12	10	120	Trace of PO_4.
5	2.1	.1	46	.2	24		77	.....	34	.....	.....	1.7	185	

a $Fe_2O_3+Al_2O_3$.

CHATTAHOOCHEE COUNTY.

GENERAL FEATURES.

Chattahoochee County is in the northwestern part of the Coastal Plain of Georgia. Its area is 218 square miles and its population (census of 1910) is 5,586. Agriculture is the chief industry.

TOPOGRAPHY.

The county is included in the topographic division here called the fall-line hills. The surface is mainly a much-dissected Coastal Plain upland of broken hilly aspect. However, in the western part of the county there are two relatively small areas of nearly level land, portions of two Pleistocene terrace plains bordering Chattahoochee River. The first (the Satilla plain) covers a few square miles in the extreme western part of the county and lies 40 to 50 feet above low-water level of the river; the second (the Okefenokee plain) covers a somewhat larger area immediately east of the first at an elevation of 140 to 170 feet above the same datum. Chattahoochee River drains the entire county, its principal tributaries being Upatoi, Oswichee, and Hichitee creeks. The maximum topographic relief is approximately 400 feet.

GEOLOGY.

The deposits of the Coastal Plain rest upon a deeply buried basement of ancient crystalline rocks, which, along the northern border of the county, lie 350 or 400 feet below low-water level of Chattahoochee River, and along the southern border probably 700 or 800 feet below the same datum plane. The Lower Cretaceous deposits, which consist of 350 or 400 feet of sands and clays, rest directly upon the basement rocks. The uppermost strata of this division appear in the bed of Upatoi Creek along the northern border of the county and doubtless extend southward under the entire county.

The Eutaw formation of the Upper Cretaceous rests unconformably upon the Lower Cretaceous deposits. The terrane consists of approximately 550 feet of strata, in part irregularly bedded sands and laminated clays and in part massive more or less calcareous and glauconitic sands and clays. Locally, the irregularly bedded portions contain lignite and concretions of iron sulphide. Massive marine beds, which make up the upper 120 feet of the formation, have been designated the Tombigbee sand member.

Conformably overlying the Eutaw formation is the Ripley formation, which is represented within the county in part by the Cusseta sand member and in part by typical marine strata. The Cusseta sand member consists of about 300 feet of fine to coarse, irregularly bedded sands and subordinate lenses of laminated or massive clay. The typical marine strata are massive, compact, calcareous, and glauconitic sands and clays. (See Pl. III, p. 52.)

Pleistocene terrace deposits consisting of loams, sands, and gravels, 20 to 35 feet thick, cover small areas in two terrace plains in the extreme western part of the county. One of these plains lies along Chattahoochee River 40 to 50 feet above low-water level; the other lies immediately to the east, 140 to 150 feet above the same datum.

Of the formations described the Lower Cretaceous deposits, the irregularly bedded portions of the Eutaw formation, and the Cusseta sand member of the Ripley formation, are the chief water bearers.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Water supplies for domestic purposes are derived chiefly from dug wells 20 to 110 feet deep, which tap water-bearing beds in the Upper Cretaceous or in the Pleistocene deposits. Wells located on the terraces, which cover 15 to 18 square miles in the western part of the county, obtain good supplies from the sands and gravels at the base of the terrace deposits at depths of 20 to 40 feet.

Small springs that are conveniently located are used, and many small creeks and headwater branches are important sources of water for stock and for local steam production.

The Lower Cretaceous deposits, which pass beneath the Upper Cretaceous beds along the northern border of the county, underlie the entire county. They carry large quantities of water of excellent quality. The Lower Cretaceous water-bearing beds dip southward, and in the upland region in the extreme south they probably lie 1,000 to 1,400 feet beneath the surface.

The irregularly bedded sands and clays of the Eutaw formation, which outcrop in the northwestern half of the county and which dip

southeast beneath the younger Cretaceous formations, contain waters of good quality and in considerable quantities. Along the southeastern border of their outcrop water-bearing strata should be reached at depths of 100 to 300 feet, and to the south or southeast in Stewart County at increasing depths to a maximum of 600 to 1,000 feet.

In the southeast corner of the county waters of good quality can be obtained from the Cusseta sand member of the Ripley formation at depths of 100 to 400 feet.

Flowing wells should be obtained on the lower levels bordering Chattahoochee River at elevations less than 50 feet above low-water level and probably also on the bottom lands of Upatoi Creek. A flowing well has been obtained on the opposite side of Chattahoochee River in Russell County, Ala., which adjoins Chattahoochee County on the west. Prof. E. A. Smith [1] describes this well as follows:

W. J. McLendon's well, near Chattahoochee River; depth 465 feet. Record: Sand and clay, 20 feet; marl with shell, 65 feet; beds of sand and marl, 15 to 25 feet thick, alternating, to 380 feet; hard rock, 2 feet; sand to 445 feet. Water at this point flowed 12 gallons per minute, but has decreased to 4 gallons. Well lowered 20 feet into sand or hard rock.

This well is located on the lowest Pleistocene terrace, at a landing 2½ or 3 miles below the mouth of Euchee Creek. Its curb is about 40 feet above low-water level. The first 20 feet of materials penetrated are Pleistocene terrace deposits; the materials from 20 to 382 feet belong to the Eutaw formation, and those from 382 to 465 feet to the Lower Cretaceous.

LOCAL SUPPLIES.

Cusseta (population 34, census of 1910).—Cusseta, the county seat, does not own a municipal water-supply system. Wells on individual properties, for the most part of the dug type, ranging in depth from 45 to 80 feet, are the chief source of water supply. The water-bearing beds tapped are either in the extreme base of the Cusseta sand member of the Ripley formation or in the uppermost part of the Tombigbee sand member of the Eutaw formation.

Rural supplies.—Two deep artesian wells have been reported from this county. McCallie [2] furnishes the following account of one of them:

The well which is located on Mr. W. C. Bradley's plantation in the western part of the county, was put down in 1897, and is reported by Mr. Bradley to have a depth of 700 feet. It is 4 inches in diameter, and the water comes to within 90 feet of the surface. The well is said to have a capacity of about 600 gallons per hour. The water is used for general domestic purposes.

[1] The underground water resources of Alabama: Alabama Geol. Survey, p. 234, 1907.
[2] Georgia Geol. Survey Bull. 15, p. 81, 1908.

The formations passed through in boring the well are reported to consist of clay, sand, and marl, no hard rock having been encountered. One water-bearing stratum occurs at 285 feet; the depths of the others are not given.

The well described by McCallie is on the Okefenokee terrace plain 1½ miles west of Shack.

During 1910 a well was drilled on the property of Mrs. L. W. Adams, 5 miles west of Cusseta. W. A. Weems, R. D. No. 2, Cusseta, furnishes the following information concerning it:

The well is located on a plain 330 feet above sea level; the depth is 385 feet and the diameter is 3 inches. The depth to the principal water-bearing bed is 110 feet; the water rises to within 35 feet of the surface and is lifted from the well by hand pump; the water is soft and of good quality and is used for domestic purposes and for watering stock. The cost of the well was $900. Rock, marl, red and white sand, and some lignite were encountered. The water-bearing bed tapped at 110 feet is in the Eutaw formation. The following analysis of water from this well, collected March 28, 1911, was made by Dr. Edgar Everhart:

Analysis of water from well of Mrs. L. W. Adams, 5 miles northwest of Cusseta.

	Parts per million.
Silica (SiO_2)	40
Iron (Fe)	16
Calcium (Ca)	2.4
Magnesium (Mg)	2.8
Sodium and potassium (Na+K)	6.0
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	37
Sulphate radicle (SO_4)	22
Nitrate radicle (NO_3)	2.0
Chlorine (Cl)	3.5
Total dissolved solids	126

A log of one of the deeper wells of the dug type is given below, the owner being authority for the lithology:

Log of well of A. K. Cook, 2 miles east of Shack.

	Thickness.	Depth.
Upper Cretaceous, Eutaw formation:	*Feet.*	*Feet.*
Sand	3	3
Clay	18	21
Sand rocks and coarse sand	20	41
Fine white sand, almost as fine as flour and as white as snow	6	47
Coarse gravel	53	100
Coarse red sand, almost as red as blood	4	104

CLAY COUNTY.

GENERAL FEATURES.

Clay County is in the west-central part of the Coastal Plain of Georgia. Its area is 203 square miles and its population is 8,960 (census of 1910). Agriculture is the chief industry.

TOPOGRAPHY.

The county lies on the border between the physiographic divisions of the fall-line hills and the Dougherty plain. The topography of the fall-line hills is characterized by hills and ridges scored by local washes and gullies, and that of the Dougherty plain by nearly level or gently rolling tracts. The former is developed in the northern part of the county and the latter in the southern, and the two merge in a northeast-southwest belt that extends through the central part of the county. The drainage of the county is chiefly through Chattahoochee River and its tributaries—Pataula, Sandy, Comochechebbee, Colomokee, and smaller creeks. The maximum surface relief is probably between 250 and 350 feet.

Two well-developed Pleistocene terrace plains, the limits of which have not been determined in detail, border Chattahoochee River in the west. The lower (the Satilla plain) lies 40 to 50 feet above low-water level; the higher (the Okefenokee plain) lies 100 to 115 feet above the same datum. The main part of the town of Fort Gaines is built upon the higher plain.

GEOLOGY.

The Ripley formation of the Upper Cretaceous outcrops in a very small area along Chattahoochee River and along Pataula Creek, in the northwest corner of the county. The materials consist of beds of massive calcareous, glauconitic, marine sands and clays, with some indurated layers. The thickness of the part of the formation appearing above water level is probably not more than 50 or 100 feet, but its total thickness, including the buried portion, is probably over 900 feet. The formation is underlain by deeply buried, older Cretaceous deposits 1,000 to 1,500 feet or more in thickness, which rest in turn upon a basement of ancient crystalline rocks. The Ripley formation dips southward beneath overlying Eocene strata and at Fort Gaines is probably first encountered in wells at a depth of 190 to 200 feet below low-water level of the river.

The Ripley formation is overlain in ascending order by the Midway formation, the Wilcox formation, and the Claiborne group, of the Eocene, and by the Vicksburg formation of the Oligocene. The Midway formation consists of several hundred feet of limestones, marls, clays, and sands, which outcrop along Chattahoochee River at

and above Fort Gaines and in small areas in the northwestern part of the county. The Wilcox formation consists of 75 to 100 feet of sandy glauconitic shell marls, dark laminated sandy clays, and gray or dark-gray glauconitic and lignitic sands, which outcrop on Chattahoochee River at and below Fort Gaines and extend northeastward through the county in a belt several miles wide. The Claiborne group consists of 150 or 200 feet of clays, sands, and marls, which come to the surface in a belt 4 to 8 miles wide, extending nearly north and south through the county.

The Vicksburg formation consists chiefly of sands and clays residual from limestones, containing greater or lesser amounts of sandy and argillaceous impurities and scattered masses of flint which resulted from the partial silicification of the original limestones. The formation outcrops in a small area in the southeast and probably does not exceed 100 feet in thickness. (See Pl. III.) Bordering Chattahoochee River thin Pleistocene terrace deposits are present in narrow areas which correspond in extent to the terrace plains.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

In the rural districts water for domestic use is obtained chiefly from shallow dug wells, 20 to 100 feet deep, and from springs. On the hilly areas the average depth of the dug wells is greater than on the terrace plains bordering Chattahoochee River.

The numerous creeks and small spring branches supply abundant water for stock and for local steam production.

The uppermost beds of the Ripley formation, which underlies the entire county, are a most promising source of artesian water. They furnish strong flows at Fort Gaines at depths of 190 to 300 feet below low-water level of the river. They would be reached at less depths north of Fort Gaines and at slightly greater depths south of that place. The middle and lower beds of the Ripley formation may be regarded as possible sources of artesian waters.

Moderate amounts of water suitable for all ordinary purposes are obtainable from the more sandy beds of the Midway and Wilcox formations and Claiborne group of the Eocene and from the Vicksburg formation of the Oligocene.

Flowing wells can probably be obtained only on the lower of the two terrace plains bordering the river, at elevations less than 50 feet above low-water level of the river, and in the bottom lands of some of the larger creeks.

LOCAL SUPPLIES.

Fort Gaines (population 1,320, census of 1910).—Several deep wells have been drilled at and near Fort Gaines, the county seat. Water is

CLAY COUNTY.

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The Ripley formation is overlain in ascending order by the Midway formation, the Wilcox formation, and the Claiborne group, of the Eocene, and by the Vicksburg formation of the Oligocene. The Midway formation consists of several hundred feet of limestones, marls, clays, and sands, which outcrop along Chattahoochee River at

and above Fort Gaines and in small areas in the northwestern part of the county. The Wilcox formation consists of 75 to 100 feet of sandy glauconitic shell marls, dark laminated sandy clays, and gray or dark-gray glauconitic and lignitic sands, which outcrop on Chattahoochee River at and below Fort Gaines and extend northeastward through the county in a belt several miles wide. The Claiborne group consists of 150 or 200 feet of clays, sands, and marls, which come to the surface in a belt 4 to 8 miles wide, extending nearly north and south through the county.

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WATER RESOURCES.

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LOCAL SUPPLIES.

Fort Gaines (population 1,320, census of 1910).—Several deep wells have been drilled at and near Fort Gaines, the county seat. Water is

obtained from horizons in the Ripley formation beneath 200 feet or more of Eocene strata. The first deep well drilled is described by McCallie [1] as follows:

> The well, which has a depth of 650 feet, was constructed in 1885 by the town of Fort Gaines, at a cost of about $2,000. The diameter of the well varies from 3 to 4 inches. The water rises to within 20 feet of the surface. Dr. J. W. Spencer, in speaking of the Fort Gaines well, says:[2] "The record of this well is lost; but it reaches a depth of 650 feet. The lower 350 or 400 feet of these strata belong to the Ripley or Upper Cretaceous system, which is overlain by the impervious beds of the lower Eocene limestones."

An analysis of water from this well is given in Table 20 (analysis 3).

In 1909 a second well was drilled at Fort Gaines under the auspices of the town government. The following information concerning it has been furnished by J. E. Paullin, chairman of the financial committee:

The well is 264 feet deep and is located near the Central of Georgia Railway station on the lowest river terrace plain about 40 or 50 feet above low-water level of the river. Water-bearing beds were encountered at depths of 230 and 264 feet, the principal supply coming from the greater depth. The 264-foot stratum furnishes a natural flow of 300 gallons per minute, which will rise at least 30 feet above the surface. The cost of the well was $2,000.

An analysis is given in Table 20 (analysis 4).

The well just described is to be the source of supply for a municipal waterworks now (1912) in course of construction. Both water-bearing beds, encountered at 230 and 264 feet are believed to be in the Ripley formation, the upper being at the extreme top of the formation. Mr. Paullin furnishes the following information concerning the proposed water-supply plant:

A tank to be installed at the well will have a capacity of 125,000 gallons. From the tank water will be pumped to a reservoir on a hill just east of the town 259 feet above the mouth of the well and 150 feet above the terrace plain on which the business part of the town stands. From the reservoir the water will be distributed by gravity through mains having a total length of about 3 miles. There will be a standpipe pressure of 65 pounds and a direct pressure from the pump of 90 pounds. The number of taps for domestic purposes will be about 100 and for manufacturing about 3; the number of fire plugs will be 25.

C. C. Greene, 934 Candler Building, Atlanta, has furnished the following information concerning a well in Clay County, 3 miles northwest of Fort Gaines:

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[1] Georgia Geol. Survey Bull. 15, p. 81, 1908.

[2] Georgia Geol. Survey First Rept. Progress, p. 79, 1891.

The well, which is owned by Mrs. C. W. Greene, of Fort Gaines, was drilled in 1910. It is on the lowest river terrace, about 40 feet above low-water level of Chattahoochee River, has a depth of 365 feet, and is 6 inches in diameter at the bottom. It flows about 165 gallons a minute. The cost was $900. The owner contemplates using the well for irrigation.

The well probably penetrated about 175 or 180 feet of strata belonging to the Midway formation of the Eocene, below which it passed through Ripley strata to the bottom. The water-bearing bed is therefore in the latter formation.

Henry County, Ala.—Flowing wells have been obtained on the lowest river terrace in Alabama opposite Clay County. G. R. Irwin, of Fort Gaines, Ga., has furnished the following information concerning his well, 2½ miles northwest of Fort Gaines, in Henry County, Ala.:

The well is 700 yards west of the river, 15 feet above high-water mark, and is 240 feet deep. A flow of 10 or 11 gallons a minute was obtained at 190 to 196 feet and 25 or 30 gallons a minute at 217 to 240 feet. Both water-bearing beds are believed to be in the Ripley formation. The following is a log of this well with a correlation of the strata:

Log of well of George R. Irwin, in Henry County, Ala., 2½ miles northwest of Fort Gaines, Ga.

	Thickness.	Depth.
	Feet.	*Feet.*
Pleistocene (terrace deposit):		
Clay and sand	30	30
Eocene, Midway formation:		
Soft lime rock	45	75
Hard lime rock	50	125
Marl	10	135
Hard lime rock	5	140
Marl	30	170
Coarse sand	10	180
Upper Cretaceous, Ripley formation:		
Hard sand rock	6	186
Coarse sand	4	190
Hard sand rock (first flow of 10 to 11 gallons a minute at this depth; measured from top of pump 7 feet above the surface)	6	196
Coarse sand	6	202
Hard sand rock	5	207
Coarse sand	3	210
Sand rock	2	212
Coarse sand	3	215
Marl	2	217
Hard sand rock with some soft spots. At 230 to 235 feet the second flow of 25 to 30 gallons a minute was encountered; flowed from top of 6-inch pipe. Well stopped in the rock	23	240

Bluffton.—According to the owner, J. E. Mansfield, a well at Bluffton, 300 yards west of the post office, 40 feet above the valley of Colomoke Creek, is of the driven type, is 60 feet deep, and is 2 inches in diameter. An abundance of water, yielded by a bed of white sand in the lower part of the well, is used for general domestic

purposes. A bed of clay containing shells was penetrated at 35 or 40 feet. The water comes from either the base of the Vicksburg formation or from the upper part of the Claiborne group. (See analysis 1, Table 20.)

Mr. Mansfield has also furnished information concerning a spring owned by the town of Bluffton, on Main Street, about 300 yards west of the post office. The spring emits a moderate stream of clear water from sand overlain by a bed of sandstone which outcrops at the base of a bluff 40 feet below the general upland level. The water is used for drinking and for general domestic purposes by the people of the neighborhood. (See analysis 2, Table 20.)

TABLE 20.—*Analyses of underground waters from Clay County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	June 1, 1911	Well of J. E. Mansfield.	Bluffton	Base of Vicksburg formation or Claiborne group?	60	Edgar Everhart.
2	do	Bluffton Spring, owned by the town.	do	Claiborne group.		Do.
3		Town well	Fort Gaines	Ripley formation	650	Do.[a]
4	June 5, 1911	do	do	do	264	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Phosphate radicle (PO_4).	Total dissolved solids.
1	12	0.2	47	2.0	14		2.0	158	8.0	0.3	3.0	.....	174
2	36	.4	3.0	Trace.	8.0		.0	18	3.0	4.0	4.0	.....	80
3	16	[b]3.6	7.0	1.4	76	9.1	98	.....	9.4	.....	20	6.3	248
4	30	Trace.	10	Trace.	67		2.0	190	11	.....	12	.....	238

[a] Georgia Geol. Survey Bull. 15, p. 82, 1908.

[b] $Fe_2O_3+Al_2O_3$.

CLINCH COUNTY.

GENERAL FEATURES.

Clinch County is in the southeastern part of the State on the Florida border. Its area is 961 square miles and its population (census of 1910) is 8,424. The county has no large towns or cities and is thinly settled. Lumber and naval stores are the chief products.

TOPOGRAPHY.

The county is a nearly even plain which slopes southward from about 200 feet above sea level in its extreme northern part to 116 feet above sea level at Fargo, in its southeast corner. Alapaha River,

which forms its western boundary, has cut 50 to 70 feet below the upland plain. Suwanee River flows through a low sand-covered terrace plain between banks or bluffs not over 10 feet high. The streams are sluggish and the waters are dark to almost black from organic matter. A relatively small area in the southeastern part of the county is covered by Okefenokee Swamp.

GEOLOGY.

Throughout the greater part of the county red and yellow argillaceous sands with thin interbedded layers of bluish clay closely underlie the surface. The thickness of these surficial materials probably does not exceed 75 feet. They are underlain by the Alum Bluff formation, comprising 150 to 250 feet of sands and greenish sandy clays, probably locally water-bearing. The Alum Bluff and the overlying beds weather to white or yellowish residual sands which cover the surface to a depth of several feet throughout the greater part of the county. The Chattahoochee formation, which underlies the Alum Bluff, does not appear at the surface but is thought to be 100 feet or more thick and to contain water-bearing beds. The Chattahoochee formation is underlain by limestones belonging to the Vicksburg formation, which is several hundred feet thick and which probably carries large quantities of water. Between the base of the Vicksburg formation and the crystalline basement rocks, the depth of which is not known, there is first a series of limestones, sands, and clays of Eocene age followed in descending order by a series of sands, clays, and marls of Cretaceous age. Both the Eocene and Cretaceous deposits probably contain water-bearing beds.

WATER RESOURCES.

None of the towns or villages of the county are equipped with public water-supply systems. Domestic water supplies are obtained chiefly from dug and driven wells 10 to 50 feet deep, which afford abundant soft water. The driven wells are preferable to the dug wells because they afford less opportunity for contamination. As there are no hard rocks near the surface driven wells are practicable throughout the county.

The waters of ponds and streams are suitable for stock and for boiler supply.

There are two deep wells in the county—one at Fargo and one at Council, 6 miles southeast of Fargo. No information has been obtained concerning them except that they are 200 or 300 feet in depth and are nonflowing.

There are numerous seepage springs throughout the county but they yield only small quantities of water and some of them are unpalatable. Some are very high in iron. A sample from a spring

near Argyle, the source of which is probably the beds overlying the Alum Bluff formation, was analyzed by Edgar Everhart in August, 1909, as follows:

Analysis of water from a spring near Argyle.

	Parts per million.
Silica (SiO_2)	7.7
Iron (Fe)	9.1
Aluminum (Al)	2.6
Calcium (Ca)	.8
Magnesium (Mg)	.5
Sodium and potassium (Na+K)	4.9
Bicarbonate radicle (HCO_3)	144
Sulphate radicle (SO_4)	1.4
Chlorine (Cl)	10
Total dissolved solids	69

COFFEE COUNTY.

GENERAL FEATURES.

Coffee County is in the so-called long-leaf pine or wire-grass region, in the southeast-central part of the Coastal Plain of Georgia. Its area is 901 square miles and its population is 21,953 (census of 1910).

TOPOGRAPHY.

The northern part is rolling to hilly. The hills present smoothly rounded, sand-covered slopes, and the valleys, except that of Ocmulgee River, are shallow. In the south the surface is flatter, presenting in places poorly drained pine and saw-palmetto flats and small, shallow, cypress ponds, which probably occupy original inequalities that have not been drained by stream erosion.

Satilla River and its tributaries form a dendritic drainage system over the greater part of the country. The interstream areas south and north of the divide between the Satilla and Ocmulgee river systems are strikingly unequal, the area south of the divide being much larger than that north of it. A similar relationship exists with respect to the areas northeast and southwest of the divide separating the Satilla and Alapaha drainage systems. The waters, except those of Ocmulgee River, are dark to almost black. The banks of the creeks and branches are low and in places the waters spread out through dense swamps through which there are no definite channels.

On the east sides of Seventeenmile Creek and Satilla and Alapaha rivers, at elevations of 40 to 50 feet above low-water level, there are belts of fluviatile sand hills half a mile to 1 mile wide.

The known elevations in the county are: Douglas, about 388; Nicholls, about 306; Ambrose, about 395; Willacoochee, 247; Kirkland, 200; Pearson, 205, and McDonald, 167.

GEOLOGY.

Ferruginous sands, with pockets and thin interbedded layers of drab or bluish clay, form the surface throughout most of the county. These materials are probably Oligocene and are similar to those of the underlying Alum Bluff formation. They are probably not more than 100 feet thick in the county. They weather to yellow or white loose quartz sand, which mantles the surface to depths of 1 foot to 6 feet. Similar sands of alluvial origin have been deposited on the terraces bordering the streams. The surficial sands have some bearing on the problems of water supply, for they are the source of small seepage springs and prevent to some extent the rapid surface drainage of rainfall.

The Alum Bluff formation, which consists of 100 feet or more of sandy clays interbedded with sands, underlies the surface materials and probably contains local water-bearing beds. The Alum Bluff formation is underlain by several hundred feet of limestones, which probably represent in descending order the Chattahoochee and Vicksburg formations of the Oligocene and the Jackson formation of the Eocene. The limestones are water bearing and constitute the most promising source of artesian water. Nothing definite is known as to the deposits beneath the limestones, but they probably consist of sands, clays, and marls of Eocene and Cretaceous age and rest at an undetermined depth upon a basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The water supply is obtained chiefly from shallow wells 30 to 50 feet deep on the higher lands or hills and 10 to 15 feet deep on the lower levels. The shallow wells furnish abundant supplies of soft water. Ponds and streams afford water for stock and boiler supply.

Small seepage springs issue from the surficial sands and sandy layers throughout the county. The most notable is Gaskins Spring, at the base of the sand hills on the eastern edge of the swamp of Seventeenmile Creek, 2 miles east of Douglas, which flows a small stream. The place is a picnic resort and camp-meeting ground and the water is used chiefly for drinking. (See analysis 2, Table 22.)

Deep wells have been drilled at Douglas, Broxton, and Willacoochee. No flowing wells have been reported.

The Oligocene and Eocene limestones are abundantly water bearing. They will be penetrated in wells at depths of 300 to 600 feet. The Alum Bluff formation, which overlies the Chattahoochee formation, is locally water bearing, and its waters, if like those from the same formation in Dodge, Telfair, Appling, and Tattnall counties, are less highly mineralized than those from greater depths.

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Conditions for obtaining flowing wells are probably unfavorable except perhaps on the low terrace or bottom lands bordering Ocmulgee River on the north.

LOCAL SUPPLIES.

Douglas (population 3,550, census of 1910).—The water supply at Douglas is obtained from an artesian well (No. 2, Table 21) owned by the town. The following account of this well is given by McCallie:[1]

It is a 6-inch well, 409 feet in depth. Water-bearing strata are reported at 325 and 390 feet. The static head of the first stratum is said to be 130 feet below the surface, and the second 170 (?) feet. The record of the well shows that clays and sands were penetrated to a depth of 130 feet, below which sand and hard rock continue to the bottom.

The well yields about 75,000 gallons of water a day and would probably yield more. (See analysis 1, Table 22.)

Broxton (population 1,040, census of 1910).—In 1908 the Dorminy-Price Lumber Co. drilled a well (No. 1, Table 21) at Broxton to a depth of 400 feet. The water is used for general domestic purposes and for boiler supply at the lumber mill.

Willacoochee (population 960, census of 1910).—An artesian well 408 feet deep (No. 3, Table 21) provides the municipal water supply of Willacoochee. The water stands within 160 feet of the surface. The daily consumption is about 25,000 gallons. (See analysis 3, Table 22.)

TABLE 21.—*Wells in Coffee County.*

No.	Location.	Owner.	Authority.	Date completed.	Approximate elevation above sea level.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
											Flow.	Pump.		
					Feet.	*Feet.*	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	Broxton	Dorminy-Price Lumber Co.	B. R. Leggett	1908	.....	400	4	400	.....	.....	.....	.....	Steam engine	
2	Douglas	Town	F. L. Swent, mayor, and S. W. McCallie.[1]	.....	388(?)	409	6	390	325	130	.....	50	.....	Analysis 1, Table 22.
3	Willacoochee	....do	The mayor and J. Wilcox.	1909	247	408	8	350	.....	160	.....	170	Steam engine	Analysis 3, Table 22.

[1] Georgia Geol. Survey Bull. 15, pp. 82-84, 1908.

TABLE 21.—*Wells in Coffee County*—Continued.

No.	Use.	Geologic horizon of principal water bed.	Character of principal water bed.	Remarks.
1	Domestic and boiler supply.	Chattahoochee or Vicksburg formation.	.....	
2	Municipal supply.	.....do.....	Sand.....	
3	.....do.....	.....do.....	.....	Cost of well, $1,500; cost of machinery, $1,400.

TABLE 22.—*Analyses of underground waters from Coffee County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	.....	Town well.....	Douglas.....	Chattahoochee or Vicksburg formation.	390	Edgar Everhart.[a]
2	Apr. 5, 1911	Gaskins Spring..	Douglas, 2 miles east of.	Surficial deposits.	.....	Do.
3	.....do.....	Town well.....	Willacoochee.....	Chattahoochee or Vicksburg formation.	350	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Remarks.
1	83	[b]34	34	7.2	12	4.6	0.0	158	2.6	.....	10	266	Free carbon dioxide (CO_2) = 42. Well 2, Table 21.
2	12	Tr.	2.0	1.0	6.0		.0	11	Tr.	1.0	5.0	36	
3	36	1	37	11	6,0		.0	160	27	.2	5.0	210	Well 3, Table 21.

[a] Georgia Geol. Survey Bull. 15, p. 83, 1908.

[b] $Fe_2O_3+Al_2O_3$.

COLQUITT COUNTY.

GENERAL FEATURES.

Colquitt County is in the south-central part of the State. Its area is 529 square miles and its population (census of 1910) is 19,789.

TOPOGRAPHY.

Colquitt County is rolling or gently undulating and there are nowhere rugged or sharply cut features. The streams are small and flow through wide swampy valleys, above which the bordering hills or ridges probably rise not more than 75 feet. No exact determinations of elevations have been made within the county, but an estimate based on known elevations in adjoining counties puts the greater part of Colquitt County 200 to 350 feet above sea level. The highest land is in the northwest.

GEOLOGY.

Ferruginous sands with interbedded layers of bluish sandy clay outcrop over the greater part of the county. They contain water-bearing beds which are tapped by many shallow wells. Beneath them is the Alum Bluff formation which outcrops in the bottoms and lower slopes of the larger streams, consists of 100 feet or more of greenish and white or drab sandy clays, sands, and sandstones, and is locally water bearing. The Alum Bluff formation is underlain by several hundred feet of water-bearing limestones interbedded with sands, which probably represent, in descending order, the Chattahoochee and Vicksburg formations of the Oligocene and the Jackson formation of the Eocene.

The aggregate thickness of the limestones probably amounts to 400 or 500 feet and they may be expected to yield large quantities of water. The Jackson formation is known to be underlain by strata of Eocene age and these in turn by strata of Cretaceous age, but definite information concerning the deposits is lacking. The Cretaceous strata probably rest upon a deeply buried surface of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

In Colquitt County dug wells 15 to 50 feet in depth are the chief source of domestic water supply, furnishing an abundance of soft water. As no hard rock is encountered such wells are dug at small expense. Small seepage springs exist but are not used extensively. The waters of ponds and streams are used to some extent for stock and for boilers. Deep wells have been reported from Moultrie, Doerun, and Norman Park.

The prospects for obtaining artesian water from the Oligocene and Eocene limestones at depths of 300 to 700 feet throughout the county are good, and it is probable that abundant supplies can be obtained at still greater depths from the Eocene and Cretaceous deposits. It is believed that flowing wells can not be obtained in the county.

LOCAL SUPPLIES.

Moultrie (population 3,349, census of 1910).—Moultrie, the county seat, owns a municipal water-supply system and obtains water from two deep wells. The first well, according to McCallie,[1] was drilled in 1897. It is 571 feet deep and is 6 inches in diameter; the principal water-bearing stratum is at a depth of 486 feet, and the water rises to within 220 feet of the surface. The following log was furnished to T. W. Vaughan by S. S. Chandler, the driller:

[1] Georgia Geol. Survey Bull. 15, pp. 84–85, 1908.

Log of town well at Moultrie (No. 2, Table 23).

	Thickness.	Depth.
	Feet.	*Feet.*
Mostly yellow clay	30	30
Clay and light-colored sand, the clay at top	55	85
A thin bed of limestone on top, gray sandstone below	55	140
Blue clay with layers of sand	180	320
Layers, with blue clay between	100	420
(The character of the material interbedded with the blue clay is not known.)		
Limestone with interbedded strata of other rock, water bearing in part	151	571

The following is an analysis, by Edgar Everhart,[1] of water from the well just described:

Analysis of water from town well at Moultrie (No. 2, Table 23).

	Parts per million.
Silica (SiO_2)	23
Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$)	6.2
Calcium (Ca)	18
Magnesium (Mg)	7.2
Sodium (Na)	24
Potassium (K)	11
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	138
Sulphate radicle (SO_4)	12
Chlorine (Cl)	9.5
Total dissolved solids	160
Free carbon dioxide (CO_2)	42

According to McCallie, the second well (No. 3, Table 23) was drilled in 1902, is 506 feet deep, and is 8 inches in diameter. The water-bearing bed tapped at a depth of 486 feet in the first well was also tapped in this well. It is believed to be in either the Vicksburg or the Jackson formation.

Doerun (population 630, census of 1910).—At Doerun domestic water supplies are derived chiefly from dug wells 25 to 60 feet deep. These wells furnish soft water. The town owns one deep well (No. 1, Table 23), completed in 1910, which is 460 feet deep and is 4 inches in diameter at the top and 3½ inches in diameter at the bottom. The water is reported to come from sand at a depth of 410 feet; it rises to within 18 feet of the surface but is lowered to 25 feet by pumping. The water-bearing stratum is probably in either the Vicksburg formation (Oligocene) or the Jackson formation (Eocene).

Norman Park (population 648, census of 1910).—Norman Park is located on the Atlanta, Birmingham & Atlantic Railroad, in the northern part of the county. The domestic water supply is derived chiefly from dug wells 15 to 40 feet deep. One deep well (No. 4, Table 23), on the campus of Norman Institute, supplies water for the

[1] Georgia Geol. Survey Bull. 15, pp. 84-85, 1908.

college and for some of the inhabitants of the village. According to F. E. McCalman this well is 585 feet deep, is nonflowing, and furnishes 350 gallons of water a minute by pumping. The water is described as hard and as having a sulphurous odor. This well probably taps a water-bearing stratum in the Jackson formation.

TABLE 23.—*Wells in Colquitt County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.
1	Doerun	Town	M. A. Jarrard	J. L. Dowling, mayor	1910
2	Moultrie	do		S. W. McCallie [a]	1897
3	do	do		do	1902
4	Norman Park	Norman Institute	Mr. Cole	F. E. McCalman	1904

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
					Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	460	3½	410	18	.....	.....	Gasoline engine	Sulphurous.
2	571	6	486	220	.....	.....	.....	Moderately hard; see analysis, p. 207.
3	506	8	486	220	.....	.....	.....	
4	585	3	329–585	.....	.....	350	Air-compressor pump	Hard, sulphurous.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Vicksburg or Jackson formation.	Sand	Cost of well, $600.
2	Municipal supply	do	Limestone?	Cased to 42 feet. See log, p. 207.
3	do	do	do	
4	Domestic	Jackson formation?	.....	6-inch casing to 256 feet; 3-inch casing to 329 feet.

[a] Georgia Geol. Survey Bull. 15, pp. 84, 85, 1908.

COLUMBIA COUNTY.

GENERAL FEATURES.

Columbia County is in the eastern part of Georgia on the border between the Piedmont Plateau and the Atlantic Coastal Plain. Its area is 350 square miles and its population (census of 1910) is 12,328. Agriculture is its chief industry.

TOPOGRAPHY.

A relatively small area in the southern part of the county lies within the Coastal Plain, the remainder forming a part of the Piedmont Plateau. The Coastal Plain area is on the northern border of the fall-line hills. Most of the drainage is through the headwater streams of Brier Creek and Spirit Creek, tributaries of Savannah

River, but a part of it passes northward through small creeks which are also tributaries of the Savannah. The surface is hilly, the maximum relief being between 150 and 200 feet.

GEOLOGY.

The ancient crystalline rocks which outcrop at the surface over the greater part of the county north of the Georgia Railroad are overlapped in the southern part of the county principally by coarse, irregularly bedded arkosic sands and interbedded light clay lenses of Lower Cretaceous age. The deposits are relatively thin, reaching a thickness of perhaps 150 or 200 feet in the extreme south. On the divide between Boggygut and Sandy Run creeks, and extending northeastward to the vicinity of Grovetown, is an overlap from the south of Eocene sands and clays of the Claiborne group which probably attains a thickness of 75 or 100 feet. (See Pl. III, p. 52.)

WATER RESOURCES.

In the Cretaceous area small springs and dug wells 10 to 100 feet deep, drawing from sand beds in the Lower Cretaceous, are the chief sources of domestic water supply. Wells at Grovetown and Harlem begin in a covering of Eocene strata of varying thickness, but most of them completely penetrate this and enter the underlying Lower Cretaceous deposits. The waters from the Lower Cretaceous sands are soft and of good quality, except where contaminated.

The deposits of the Coastal Plain do not develop important artesian pressure within the county. The water table is low and only moderate amounts of water are available.

CRAWFORD COUNTY.

GENERAL FEATURES.

Crawford County is in the west-central part of the State on the border between the Piedmont Plateau and the Atlantic and Gulf Coastal Plain. Its area is 319 square miles and its population (census of 1910) is 8,310. Agriculture and horticulture are the chief industries.

TOPOGRAPHY.

The portion of the county included in the Coastal Plain forms a part of the fall-line hills. The drainage of the Coastal Plain area is received in part by Flint River through its tributary, Spring Creek, and in part by Ocmulgee River through its tributaries, Echeconnee and Mossy creeks.

In general the surface is hilly, but on the divide between the Flint and Ocmulgee river systems there are small areas of the original

upland plain which have been only slightly dissected. The maximum topographic relief probably does not exceed 300 feet.

Locally there are thin accumulations of loose, gray, surficial sand which is residual from older formations, but which has undergone more or less shifting by winds and torrents.

GEOLOGY.

The northern part of Crawford County, embracing less than half the total area, lies within the Piedmont Plateau, and the remainder of the county lies within the Coastal Plain. The crystalline rocks, which appear at the surface in the Piedmont Plateau, pass southward beneath the deposits of the Coastal Plain and form the basement upon which the latter rest.

Deposits of Cretaceous, Eocene, and Pleistocene age are present in the Coastal Plain area. The Lower Cretaceous deposits, which consist of several hundred feet of coarse, irregularly bedded, arkosic sands, with subordinate lenses of light drab to white clay, rest immediately upon the crystalline rocks and appear at the surface in a belt 3 to 6 miles wide along the northern border of the Coastal Plain.

These deposits are unconformably overlain by irregularly bedded coarse to fine sands and laminated to massive clays belonging to the Cusseta sand member of the Ripley formation, which may reach a thickness of 150 or 200 feet within the county. The member appears at the surface in a belt several miles wide along the southeastern side of the county.

The Cusseta sand is unconformably overlain, over a part of the area, by 15 to 25 feet of red ferruginous sand referable to the Claiborne group of the Eocene. In a small area, perhaps a few miles square, known as Rich Hill, about 5 miles southeast of Roberta, Eocene strata belonging to the Jackson formation rest unconformably upon the Lower Cretaceous sands and clays. (See Pl. III, p. 52.)

On the lower levels bordering Flint River thin Pleistocene terrace deposits have been laid down in small areas.

WATER RESOURCES.

No deep artesian wells have been reported from the portion of the county lying within the Coastal Plain. Supplies for domestic purposes are obtained entirely from dug wells 25 to 100 feet or more in depth and from small springs. Waters from both wells and springs are in general of good quality and are commonly soft.

No springs of especial note have been reported. Small springs, emitting as a rule not more than 10 or 12 gallons of water per minute, are fairly numerous.

Detailed information concerning several dug wells is included in Table 24 (Nos. 1–8), and from this an idea may be had of the supply of the region. Logs of two of the wells are given below, the owners being authority for the lithology:

Log of well of Isaac Miller, 4½ miles northwest of Fort Valley (Crawford County) (No. 1, Table 24).

	Thickness.	Depth.
Eocene?:	*Feet.*	*Feet.*
Clay	25	25
Upper Cretaceous, Ripley formation, Cusseta sand member:		
Yellow sand	50	75
White sand with some purple sand	15	90
Dark gravel and rocks [pebbles?]	10	100
Lower Cretaceous?:		
"Chalk" [clay]	3	103

Log of well of J. W. George, half a mile south of Leepope (No. 2, Table 24).

	Thickness.	Depth.
Eocene?:	*Feet.*	*Feet.*
Soil	2	2
Stiff red clay	20	22
Upper Cretaceous, Ripley formation, Cusseta sand member:		
"Chalk" [clay] and gravel	10	32
Coarse sand and gravel, some water	3	35
Blue "chalk" [clay]	12	47
Coarse brown sand	18	65
White and blue sticky "chalk" [clay]	3	68
Fine sand and gravel, water bearing	4	72
Sand rock.		

The clay at the bottom of the section first given may correspond to the clay at the base of the section in the railway cuts north of Zenith. It is therefore tentatively referred to the Lower Cretaceous.

Numerous small creeks and branches in the Coastal Plain area afford ample supplies of excellent water for stock and for steam production.

The Cretaceous deposits which underlie the southern part of the county, and which include the Lower Cretaceous deposits and the Cusseta sand member of the Ripley formation (Upper Cretaceous), contain numerous coarse beds of sand capable of carrying large quantities of water. These are reached at shallow depths along the northern border of the area and at increasingly greater depths southward. They would be tapped along the southeastern border of the county at depths of 100 to 500 feet. The water from these beds would be soft and of good quality.

Although no flowing wells have been reported it may be possible to obtain such in the bottom lands bordering Flint River in the extreme south.

TABLE 24.—*Wells in Crawford County.*

No.	Location.	Owner.	Authority.	Date completed.	Approximate elevation above sea level.
					Feet.
1	Fort Valley, 4½ miles northwest of	Isaac Miller	Owner	1890	535
2	Leepope, ½ mile south of	J. W. George	do	1898	550
3	Leepope, ½ mile southeast of	L. H. George	do		540
4	Leepope	Leepope Fruit Co	W. H. McCarty, Leepope, Ga.		545
5	Roberta, ¼ mile southwest of	Wm. J. Dent	Owner	1891	
6	Roberta	J. S. Sandefur & Co.	Wm. J. Dent		
7	Zenith, 1 mile northwest of	Phil Ogletree	Owner		575
8	Zenith, ¼ mile northeast of	Mrs. C. E. Pearson	A. B. Young, Zenith, Ga.	1890	575

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute by pumping.	How obtained.	Quality.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*			
1	103	3	100				Suction pump, gasoline engine.	
2	72	3	70.5	35	69	Small	Bucket and rope	
3	56	[a] 4 [b] 3	55		50–56	4 gallons	Gasoline engine	
4	57	[a] 6 [b] 3½	55		45–52		Gasoline engine and windmill.	Ferruginous.
5	45	3	42		38–43	Abundant	Hand pump	
6	30	6	26		26	do	Suction pump	
7	45	3	42		40		Gasoline engine	Soft.
8	70	3	68		68–70	Small	Bucket and rope	

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Cusseta sand member of Ripley formation.	Gravel	Dug. See section, p. 211.
2	do	do	Sand and gravel	Dug. Yield is decreased by drouth; see section, p. 211.
3	do	do	Sand	Dug. Cost of pump, $40.
4	do	do	do	Dug. Supplies 20 to 200 people and 30 head of stock.
5	do	Lower Cretaceous	do	Dug. Can not be exhausted with hand pump. Six similar wells in immediate vicinity.
6	Boiler supply	do	Sand and gravel?	Dug. Supplies water to boilers of large cotton gin, sawmill, and planing mill.
7	Domestic	Lower Cretaceous?	Sand and gravel	Dug. Cribbed with wood 20 feet. Cost of pumps, $200.
8	do	Lower Cretaceous.	Sand	Dug. Cribbed from top to bottom.

[a] Diameter at top of well. [b] Diameter at bottom of well.

CRISP COUNTY.

GENERAL FEATURES.

Crisp County is in the west-central part of the Coastal Plain of Georgia. Its area is 277 square miles and its population (census of 1910) is 16,423. Agriculture is the principal industry, and lumbering,

though declining, is still carried on to an important extent. Cordele, the county seat, is 65 miles south of Macon. It has an ice factory, a cotton-cloth mill, a cottonseed-oil mill, a fertilizer factory, and other smaller manufacturing plants.

TOPOGRAPHY.

The county is nearly level to slightly rolling. The western part, from a few miles west of Cordele to Flint River, is directly underlain by limestone and the surface is nearly level but has some lime sinks. Flint River is bordered by two Pleistocene terrace plains. The first lies 15 to 20 feet above the river level and is well defined; the second lies about 60 feet above the same datum, and although somewhat modified by erosion is easily recognizable. The elevation of this part of the county is estimated to be between 200 and 300 feet above sea level. The eastern part of the county is directly underlain by sands and clays and presents the low, smoothly rounded hills or undulations and the shallow dish-shaped valleys peculiar to the Altamaha upland or wire-grass region. This area is estimated to lie 300 to 400 feet above sea level.

GEOLOGY.

The Vicksburg formation, which consists of 150 feet or more of soft, cavernous, water-bearing limestones interbedded with sands and clays, forms the surface terrane in the western part of the county. It is overlain by the Chattahoochee formation, which consists of 100 feet or less of limestones, sands, and clays similar to those composing the Vicksburg, and which outcrops in a limited area in the southwest-central part of the county east of the belt of outcrop of the Vicksburg. The Chattahoochee formation is overlain by 50 or 100 feet of sands and sandy clays of the Alum Bluff formation, which outcrops in a narrow area east of the outcrop of the Chattahoochee formation. The Alum Bluff formation is overlain by 50 to 100 feet of sandy clays and sands, which appear at the surface over approximately the eastern half of the county.

Beneath the Vicksburg formation, but not appearing at the surface in the county, are undifferentiated deposits of Eocene age, probably representing the Jackson formation, the Claiborne group, and the Wilcox and Midway formations, all of which contain water-bearing beds. The Eocene deposits are underlain by deposits of Cretaceous age, which aggregate probably 1,500 to 2,500 feet in thickness and which contain water-bearing beds. The Cretaceous deposits rest upon a deeply buried basement of crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

In the rural districts dug wells 20 to 50 feet deep are the source of water for general domestic use. The water of creeks and ponds is used to some extent for stock.

There are small seepage springs and a few bold limestone springs. At Cordele the municipal water supply was formerly derived from a large spring in the northwestern part of the city, but this became polluted and was abandoned.

It is believed that large supplies of artesian water can be obtained anywhere in the county at depths not exceeding 500 feet, but these waters are apt to be hard. Waters containing smaller amounts of mineral matter can probably be obtained at greater depths from the Eocene and Cretaceous deposits.

Flowing wells are obtained in the western part of the county, and estimates based on the height to which the water rises in the city wells at Cordele, show that flows can be obtained in the vicinity in places where the surface is 35 or 40 feet lower than that of the Georgia Southern & Florida Railway station.

LOCAL SUPPLIES.

Cordele (population 5,883, census of 1910).—The municipal water supply of Cordele is derived from three wells (Nos. 11–13, Table 25), located near the railway station about 326 feet above sea level.

The first well (No. 12, Table 25) was drilled in 1890, but was later abandoned. It is reported to have been 550 feet deep and to have found water which rose to within 20 feet of the surface. J. W. Spencer[1] gives the following record:

Partial log of first city well at Cordele (No. 12, Table 25).

	Thickness.	Depth.
	Feet.	*Feet.*
Soil, clay, and "chalk"	40	40
Coarse red sand	20	60
Loose bowlder rock, through which the tubing was driven (fine white sand was also found)	8	68
Different colored marls (clays or true marls?)	100	168
Limestone and shell rock with an intervening layer of sand	232	400
Sand and shell rock	75	475
Quicksand	60	535

The well may have penetrated the top of the Ripley formation of the Upper Cretaceous, but definite proof is lacking.

The second well (No. 13, Table 25), drilled in 1900, is 396 feet deep (400 feet?) and 8 inches in diameter. Its daily yield is 300,000+ gallons. (See analysis 2, Table 26.)

[1] Georgia Geol. Survey First Rept. Progress, p. 79, 1891.

Information concerning the third city well (No. 11, Table 25) has been furnished by J. A. Littlejohn, the county clerk. The principal water-bearing bed is at a depth of 735 feet and is believed to be in the Ripley formation. (See analysis 3, Table 26.)

For comparison with the waters from the deeper wells a sample of water from a well (No. 14, Table 25) of lesser depth at Cordele was analyzed (Table 26, analysis 4). This well is owned by J. W. Cannon and is located in the eastern part of the city; its depth is 155 feet and its diameter is 4½ inches, and it yields by pumping about 17 gallons per minute. The static level of the water is at 57 feet beneath the surface.

Coney and vicinity.—Several artesian wells at and near Coney (Nos. 2–10, Table 25) range in depth from 216 to 360 feet, and most of them flow small streams a few feet above the surface. The wells yield clear, potable waters which give off an odor of hydrogen sulphide. An analysis of water from a spring 2 miles west of Coney, owned by the Georgia Land Corporation, is given in Table 26 (analysis 1). The source of this spring is probably the Vickburg formation.

Logs of several wells near Coney are as follows: [1]

Log of J. M. Campbell's well at Coney (No. 4, Table 25).

	Thickness.	Depth.
	Feet.	*Feet.*
Yellow clay	20	20
Soft limestone	25	45
Hard, compact limestone	6	51
Limestone containing shells	40	91
Blue clay	45	136
Hard, compact limestone	8	144
Blue clay	36	180
Limestone with shells	20	200
Marl and coarse sand to bottom of well	85	285

Partial log of well owned by Daniel Wells, 3 miles west of Coney (No. 6, Table 25).

	Thickness.	Depth.
	Feet.	*Feet.*
Yellow clay	12	12
Limestone	28	40
Subterranean cavity	8	48
Limestone	8	56
Pebbles	5	61
Clay	28	89
Limestone	2	91
Bluish clay	40	131
Limestone	14	145
Dark-colored sand; shells with sharks' teeth	71	216
Flint	1.5	217.5
Dark-colored sand	3	220.5
Limestone	(?)	(?)
Bottom of well	.....	336

[1] Georgia Geol. Survey Bull. 15, pp. 92-94, 1908.

Log of P. C. Clegg's well, 6 miles west of Coney (No. 7, Table 25).

	Thickness.	Depth.
	Feet.	*Feet.*
Gray sandy clay	15	15
Blue clay	81	96
Limestone	12	108
Coarse sand	15	123
Fossiliferous limestone	20	143
Blue clay	50	193
Shell rock and coral	16	209
Flint, in thin layers of limestone to the bottom of the well	7	216

Partial log of James Byrom's well near Coney (No. 8, Table 25).

	Thickness.	Depth.
	Feet.	*Feet.*
Yellow clay	54	54
Limestone	28	82
Cavity	8	90
Limestone	10	100
Cavity	14	114
Bluish clay	40	154
Dark-colored sand	100	254
Limestone	6	260
Cavity	5	265
Limestone	7	272
Flint	2	274
Fine white sand	28	302
Flint	2	304
Dark-colored sand and pebbles	(?)	(?)
Bottom of well	.....	360

TABLE 25.—*Wells in Crisp County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Arabi	R. A. Bedgood	.....	S. W. McCallie[a]	1890	399
2	Coney	S. W. Coney	.....	....do	1896	.....
3	....do	J. B. Lewis	.....	....do	.....	.....
4	....do	J. M. Campbell	.....	....do	.....	.....
5	....do	S. E. Cunningham	H. R. Teal, Richwood, Ga.	W. H. Cunningham.	1900	(b)
6	Coney, 3 miles west of.	Daniel Wells	.....	S. W. McCallie[a]	.....	.....
7	Coney, 6 miles west of.	P. C. Clegg	.....	....do	.....	.....
8	Coney, 2 miles west of.	James Byrom	.....	....do	.....	.....
9	Coney, 4 miles northwest of.	S. C. Clegg	.....	S. W. Coney	.....	.....
10	Coney, 2 miles west of.	Georgia Land Corporation.	John Cole	W. H. Byrom	1909	.....
11	Cordele	City	John E. Cole	J. A. Littlejohn	1905	326
12	....do	....do	.....	S. W. McCallie[a]	1890	326
13	....do	....do	.....	R. W. Barwick, superintendent of waterworks.	1897	326
14	Cordele, 1 mile east of.	J. W. Cannon	F. E. Fenn	Owner	1911	.....
15	Penia	.....	.....	S. W. McCallie[a]	.....	375

[a] Georgia Geol. Survey Bull. 15, pp. 91–94, 96–97, 1908.
[b] Mouth of well 15 feet above Seaboard Air Line Ry. track at railroad station.

TABLE 25.—*Wells in Crisp County*—Continued.

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	298	6	.....	.....	.....	.....	.....	.....	
2	278	6	.....	.....	+ 3	15	.....	Flows.	
3	360	.....	340	150, 225	− 6	.....	15	.....	
4	285	.....	.....	.....	+ 4	.....	.....	Flows.	
5	250	3½	240–250	.....	+ 1.2	35	.....	....do.....	Sulphurous.
6	336	3	.....	.....	+ 5	.....	.....	....do.....	
7	216	4	200	60, 96	+ 4	6	.....	....do.....	
8	360	2	.....	.....	+ 8	.....	.....	....do.....	
9	290	4	.....	.....	+ 2½	.....	.....	....do.....	
10	230	3	.....	.....	+ 3½	100	.....	....do.....	Soft.
11	735	6	735	160 400 600	−32	500	.....	Air-lift pump.....	Analysis 3, Table 26.
12	550	.....	.....	.....	− 20	.....	.....	.....	
13	396	8	375	.....	− 18	.....	200+	.....	Analysis 2, Table 26.
14	155	4½	67	.....	− 57	.....	17	Gasoline engine...	Analysis 4, Table 26.
15	320	4	.....	.....	−120	.....	.....	.....	

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	.....	Jackson formation?	.....	
2	Domestic.....	.....do.....	.....	
3	.....	.....do.....	.....	
4	.....	.....do.....	Marl and coarse sand.	
5	Domestic and boiler supply.	.....do.....	Hard rock.....	3½-inch casing to 240 feet. Cost of well, $250.
6	.....	.....do.....	Limestone	
7	.....	.....do.....	.....do.....	
8	.....	.....do.....	.....	
9	.....	.....do.....	.....	
10	Domestic.....	.....do.....	Sand	4 wells. Cost of well, $300.
11	Municipal supply.	Ripley formation?.	Limestone	6-inch casing to 600 feet. Cost of well, $300; cost of machinery, $1,700.
12	.....	Eocene.....	Quicksand.....	Abandoned.
13	Municipal supply.	Vicksburg formation?	.....	8-inch casing to 180 feet.
14	Domestic.....	Alum Bluff formation?	Sand and marl....	4½-inch casing to 69 feet. Cost of well and machinery, $750.
15	.....	Vicksburg formation?	.....	

TABLE 26.—*Analyses of underground waters from Crisp County.*

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	June 10, 1911	Spring of Georgia Land Corporation.	Coney, 2 miles west of.	Vicksburg formation?	.....	Edgar Everhart.
2	.....	Town well.....	Cordele.....	.....do.....	375	Do.[a]
3	Apr. 18, 1911	.....do.....	.....do.....	Ripley formation?	735	Do.
4	May 20, 1911	Well of J. W. Cannon.	Cordele, 1 mile east of.	Alum Bluff formation?	67	Do.

[a] Georgia Geol. Survey Bull. 15, p. 92, 1908.

TABLE 26.—*Analyses of underground waters from Crisp County*—Continued.

[Parts per million.]

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Remarks.
1	34	0.4	56	0.4	6.0	Trace.	159	9.0	0.2	4.5	196	
2	11	[a]2.9	44	1.1	4.6	0.0	134	4.4	.....	5.6	141	No. 13, Table 25. Free carbon dioxide=2.
3	39	1.2	46	5.2	5.8	.0	195	6.4	.....	5.5	261	No. 11, Table 25.
4	9.0	.2	44	Trace.	11	.0	150	8.0	1.0	3.5	172	No. 14, Table 25. Total depth, 155 feet.

[a] $Fe_2O_3+Al_2O_3$.

DECATUR COUNTY.

GENERAL FEATURES.

Decatur County is in the extreme southwestern part of the State, adjacent to Florida and Alabama. Its area is 823 square miles and its population is 29,045 (census of 1910). Agriculture is important and the production of lumber and naval stores is extensive. Manufacturing establishments at Bainbridge include cottonseed-oil mills, a foundry, an ice factory, a cooperage works, and smaller plants.

TOPOGRAPHY.

The eastern and western parts of the county present different topographic aspects. The western part, which lies mainly west of Flint River, but includes also small areas on the east side of the river north of Bainbridge, is nearly level and lies for the most part between 100 and 150 feet above sea level. Lime sinks and ponds are common, and the area is notable for the absence of small tributary creeks and branches, a part of the drainage being underground. Chattahoochee River has only small, unnamed tributaries within the county.

The surface in the eastern part of the county lies 200 to 300 feet above sea level, is rolling or broken, and is drained by small creeks and branches. This higher land is separated from the lower land in the west by a pronounced escarpment which extends northeastward from the southwest corner of the county to a point within 7 miles of Bainbridge, whence it continues to the northeast corner of the county. The escarpment is well marked west of Climax. The difference in elevation between Bainbridge on Flint River and Climax, 9 miles away, is 175 feet, the greater part of this ascent being in the first 2 or 3 miles west of Climax. The difference between the eastern and western parts of the county is due in part to differences in the surface formations and in part to differences in elevation; in the east the

surface is higher and is underlain by sands and clays; in the west the low plain is underlain by soft limestones.

Chattahoochee River is bordered by two Pleistocene terrace plains, one lying 20 or 30 feet and the other 75 or 80 feet above the river. Flint River is also bordered by two terrace plains, one lying 15 or 20 feet and the other 40 or 50 feet above the river.

GEOLOGY.

The Vicksburg formation, which consists of at least 400 feet of soft, cavernous, water-bearing limestones, outcrops throughout approximately the northwestern half of the county. The beds dip southward 2 or 3 feet to the mile, passing beneath the Chattahoochee formation, which consists of about 100 feet of limestones, outcropping in an irregular belt 1 to 6 miles wide, extending northeast and southwest through the central part of the county. The Alum Bluff formation, which consists of 100 or 150 feet of drab sandy clays and quartz sands, overlies the Chattahoochee formation and outcrops in an irregular belt 2 to 5 miles wide southeast of the Chattahoochee belt and in the small headwater valleys of Little River in the southeastern part of the county. The deposits contain water-bearing beds. The Alum Bluff formation is overlain by 50 to 75 feet of irregularly bedded sands and clays, in part water bearing, which outcrop over the remainder of the southeastern part of the county. The geologic age of these beds is not positively determined.

The Vicksburg formation is underlain by several hundred feet of undifferentiated Eocene strata which are water bearing in part and are in turn underlain by undifferentiated Cretaceous strata, also believed to be water bearing. At an unknown depth the Cretaceous rocks rest upon a basement of ancient crystalline rocks. (See Pl. III.)

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

In the western part of the county the dug wells range in depth from 40 to 75 feet. Wells that penetrate only the residual sands and clays resulting from the weathering of the limestone of the Vicksburg formation yield soft waters, and those that pass through the residual materials and enter the underlying limestones yield hard waters. In the eastern part of the county the wells are somewhat shallower and commonly yield softer waters.

In the vicinity of Donaldsonville, Iron City, Brinson, Reynoldsville, and Boyettville drilled wells ranging in depth from 100 to 500 feet reach the limestones at depths of 60 to 100 feet and obtain water which rises to within 40 or 50 feet of the surface.

Many limestone springs and small seepage springs are used locally for domestic purposes. The largest are Russell Springs, near the

mouth of Spring Creek, and Blue Spring, 4 miles south of Bainbridge, both of which yield large quantities of water and seem to be the outlets of underground streams. They belong to the type of large limestone springs common in southern Georgia and Florida. Most of the springs of the western part of the county yield hard water. The waters of creeks and ponds are utilized in a small way for stock and boiler supply.

Artesian water can be obtained throughout the county at depths of 100 to 1,000 feet or more. With the possible exception of wells 1,200 to 2,000 feet or more in depth the static head will not be sufficient to lift the water above the surface. Flint River is bordered by a tract of land lying approximately 100 feet above sea level, in which flowing wells can probably be obtained from the deeply buried Eocene or Cretaceous deposits which yield flows in the adjoining counties of Baker, Calhoun, and Dougherty. A similar narrow strip of low-lying land borders Spring Creek. It is possible that wells drilled to the greater depths mentioned may yield flows on some of the low, nearly level interstream areas.

LOCAL SUPPLIES.

Bainbridge (population 4,217, census of 1910).—Bainbridge owns three artesian wells. At present the principal supply is obtained from one well (No. 2, Table 27).

The following record of this well was furnished to T. W. Vaughan by S. S. Chandler:

Log of city well at Bainbridge (No. 2, Table 27).

	Thickness.	Depth.
	Feet.	*Feet.*
Surface sands and clays	70	70
Limestone	165	235
Light-colored sandstone	30	265
Limestone with shells?	186	451
Sand at bottom	1	452

Spencer [1] gives the following data regarding the old city wells, one of which is 900 feet deep and the other 1,250 feet deep:

Log of 900-foot well at Bainbridge (No. 3, Table 27).

	Thickness.	Depth.
	Feet.	*Feet.*
Sand and clayey sand	75	75
Limestone (the upper 200 feet the softer), no clay layers	700	775
Soft limestone	50	825
Quicksand to bottom of well	75	900

[1] Spencer, J. W., Georgia Geol. Survey First Rept. Progress, 1890-91, p. 55.

A second well was sunk within 3 feet of the first, which penetrated below the limestone to a depth of 425 feet [total depth, 1,250 feet] in quicksand. Sharks' teeth, lignite, and pyrite concretions came from some of the layers of sand. Several cavities in the limestone were passed through, the deepest being 3 feet.

Analyses of the waters from these wells are given in Table 28 (analyses 1 and 2).

Donaldsonville (population 747, census of 1910).—Drilled wells ranging in depth from 100 to 500 feet are the principal source of water. The town owns a system of waterworks and consumes about 30,000 gallons of water a day, derived from wells.

The wells are reported to enter rock at depths of 75 to 100 feet, and the water is said to rise to within 20 to 30 feet of the surface. An analysis of water (No. 3, Table 28) from a deep well at Donaldsonville was made several years ago by H. C. White, but the depth from which the water was obtained is not given. McCallie [1] gives the log of a well at this place as follows:

Log of well at Donaldsonville.

	Thickness.	Depth.
	Feet.	*Feet.*
Varicolored sands and clays	45	45
Sand and limestone, the latter made up largely of Nummulites	5	50
Fine white sand and clay	90	140

Iron City (population 459, census of 1910).—At Iron City drilled wells 150 to 175 feet deep are the principal source of water. These wells, which are reported to enter limestone at 60 to 100 feet, yield hard water. The public supply is pumped from a well and distributed from a tank; the consumption is about 8,000 gallons a day.

Lela.—The following log of a well (No. 8, Table 27) owned by the Chattahoochee Lumber Co., at Lela (3 or 4 miles southwest of Iron City), is adapted from a log published by Fuller and Sanford: [2]

[1] Georgia Geol. Survey Bull. 15, p. 87, 1908.

[2] Fuller, M. L., and Sanford, Samuel, Record of deep-well drilling for 1905: U. S. Geol. Survey Bull. 298, p. 200, 1906.

Log of well owned by Chattahoochee Lumber Co. at Lela (No. 8, Table 27).

[Samples furnished by Hughes Specialty Well Drilling Co., Charleston, S. C.]

	Thickness.	Depth.
	Feet.	*Feet.*
Soft white clay with red streaks; coarse white sand and fine gravel	20	20
Soft gray and buff sandy clay; soft water in large supply	20	40
Soft, creamy-white, sandy limestone, containing Nummulites	100	140
Soft brownish limy sandstone containing Nummulites	20	160
Soft light-brown, sandy limestone, containing Nummulites	20	180
Soft light-gray limestone, containing dark-green grains	20	200
Soft white to light-buff sandy limestone containing Nummulites, Orbitoides, and Bryozoa	20	220
Soft greenish marl containing Nummulites? and Bryozoa	20	240
Hard white to grayish-brown sandy limestone containing Nummulites and Bryozoa	20	260
Soft white marl, may contain glauconite	60	320
Fine gray sand; contains glauconite and bits of shells; some water	60	380
Hard, light-brown, sandy limestone containing Nummulites and Orbitoides	20	400
Medium to fine, light-gray sand; contains glauconite and bits of shells; has hard layers	60	460
Same sand, with very little glauconite	60	520
Fine to medium gray sand containing layers of rock (probably white limestone) and very few grains of glauconite	60	580
Same sand and rock with more glauconite	140	720
Soft dark marl (no sample); water bearing at 737 feet	198	918

Rig used, hydraulic. Diameter of well, 6 and 2 inches. Casing used, 600 feet of 3-inch. Main supply of water from 737 feet. Water rises within 10 feet of surface. Yield, about 15 gallons per minute.

The well probably penetrates to the lower part of the Eocene deposits or to the upper part of the Cretaceous deposits. A partial set of borings from the well is on file in the office of the United States Geological Survey (well No. 817). Specimens of Bryozoa obtained between 200 and 260 feet are related, according to R. S. Bassler, to the bryozoan fauna of Jackson age (Eocene) obtained from limestone at Wilmington, N. C., and may indicate either a Jackson or a Vicksburg age. Specimens of Nummulites obtained from the same set of borings between the depths 60 and 400 feet, identified by Dr. J. A. Cushman, indicate, according to Dr. Vaughan, the Vicksburg age of the strata to this depth.

TABLE 27.—*Wells in Decatur County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Amsterdam	A. Cohn & Co.		Postmaster.		
2	Bainbridge	City	Mr. Van Fleet	T. B. Maxwell	1900	110
3	do	do		J. W. Spencer [a]		118
4	do	do		do		118
5	Boyettville		Mr. Mosley	R. F. Kinley		
6	Donaldsonville			Postmaster		139
7	Iron City			do		
8	Lela	Chattahoochee Lumber Co.	Hughes Specialty Well Drilling Co., Charleston, S. C.	Hughes Specialty Well Drilling Co. of Charleston, S. C., and the postmaster of Iron City.	1905	
9	Reynoldsville			Postmaster		

[a] Georgia Geol. Survey First Rept. Progress, pp. 54–55, 1891.

TABLE 27.—*Wells in Decatur County*—Continued.

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	700	.....	.....	.....	200	.....	.....	Air-lift pump.....	
2	452	.....	.....	.....	50	.....	.....	Steam engine.....	Soft.
3	900	.....	.....	280–370	50	.....	.....	.....	Analysis 1, Table 28.
4	1,250	.....	.....	370	50	.....	.....	.....	Analysis 2, Table 28.
5	150	.....	100	150	15	.....	.....	.....	
6	500	.....	500	.....	20–30	.....	.....	.....	Hard.
7	175	.....	150	.....	40	.....	15	Pump.....	Slightly hard.
8	918	2	737	40 50–60	10	.....	15	.....	
9	200	.....	200	.....	.....	.....	25	.....	Hard.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Municipal supply, manufacturing.	Eocene.....	.....	
2	Municipal supply.	Eocene?	.....	See log, p. 220.
3	Domestic.....	Eocene.....	.....	Do.
4	.....do.....	Eocene?	.....	
5	Domestic, manufacturing.	Vicksburg formation.	Limestone.....	Cost of well and machinery, $150.
6	Boiler supply, domestic.	Eocene.....	Rock.....	
7	Domestic, manufacturing.	Vicksburg formation.	Limestone.....	
8	Abandoned.....	Eocene?	.....	8-inch casing to 80 feet; 3-inch casing to 602 feet; 2-inch casing to 740 feet. See log, p. 222.
9	Domestic.....	Vicksburg formation.	.....	

TABLE 28.—*Analyses of underground waters from Decatur County.*

[Parts per million.]

No.	Source.	Location.	Principal water-bearing-stratum.	Depth of well.	Analyst.
				Feet.	
1	Town well.....	Bainbridge.....	Eocene.....	900	H. C. White.[a]
2	.....do.....	.....do.....	Eocene(?)	1,250	Do.
3	Well of Chattahoochee Lumber Co.	Donaldsonville.....	.....	(?)	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	3.9	9.8	62	4.6	26		85	58	.....	21	.....	293	No. 3, Table 27.
2	4.0	.1	29	.1	57		82	32	.....	17	1.0	221	No. 4, Table 27.
3	38	[b].3	26	6.3	8.3	1.4	.....	11	1.0	9.1	.....	.....	Total hardness as $CaCO_3$, 71; permanent hardness as $CaCO_3$, 32.

[a] Georgia Geol. Survey Bull. 15, pp. 87-89, 1908.

[b] $Fe_2O_3+Al_2O_3$.

DODGE COUNTY.

GENERAL FEATURES.

Dodge County is in the north-central part of the Coastal Plain of Georgia. Eastman, the county seat, is 63 miles a little east of south of Macon. The area of the county is 431 square miles and the population (census of 1910) is 20,127. Agriculture is the principal industry, but lumber and naval stores are produced in important quantities. The chief industrial use to which water is put is for boiler supplies at cotton gins and sawmills.

TOPOGRAPHY.

The county is nearly level to slightly rolling or undulating. The valleys are shallow and their slopes gentle. Limestone lies near the surface in the west and some lime-sink depressions occur. With the exception of the bottom lands along Ocmulgee River, which are probably less than 200 feet above sea level, the elevation of the county is estimated to be 300 to 400 feet.

GEOLOGY.

The Vicksburg formation (of Oligocene age), which consists of 100 feet or less of limestones with interbedded layers of sand and clay, outcrops in the valley of Ocmulgee River in the northwestern part of the county; the strata dip slightly southward and underlie the remainder of the county beneath younger formations.

The Vicksburg formation is overlain by probably not more than 100 feet of the lithologically similar Chattahoochee formation (of Oligocene age), which outcrops in the valley of Ocmulgee River in the southwest. Both the Vicksburg and Chattahoochee formations contain important water-bearing beds.

In the southern part of the county the Chattahoochee formation is overlain by the Alum Bluff formation (of Oligocene age), which consists of 150 or 200 feet of bluish sands and clays, in part water bearing.

Overlapping the Alum Bluff, Chattahoochee, and Vicksburg formations and constituting the surface deposits throughout the greater part of the county is 75 feet or less of irregularly bedded sands and clays, with subordinate lenses of claystone and conglomerate, the geologic age of which is not positively known. The water obtained in the shallow wells is derived from these surficial deposits.

The Vicksburg formation is probably underlain by limestones belonging to the Jackson formation, which is in turn underlain by several hundred feet of undifferentiated deposits of Eocene age. The Eocene is underlain by 1,000 feet or more of undifferentiated deposits of Cretaceous age, which rest upon a basement of ancient

crystalline rocks. Although the Eocene and Cretaceous deposits do not appear at the surface within the county, they contain deeply buried water-bearing beds of importance.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug wells, 10 to 50 feet deep, are the principal source of water for domestic use. They supply a water that is reported to be soft and that should be wholesome if the wells are properly located and protected from surface drainage by casing and curbing. There are some small springs, most of which are unimportant as sources of water supply, though two of them, Jaybird Spring, 4 miles east of Chauncey, and Wild Rose Mineral Spring, near Southerland, supply waters that are sold for drinking. (See p. 226; also Table 30, analysis 2.) Deep wells have been drilled at Eastman, Chauncey, Chester, and Rhine.

Artesian water can be obtained from the limestones of the Chattahoochee, Vicksburg, and Jackson formations, and from the deeply buried Eocene and Cretaceous deposits, but the prospect for obtaining flows is poor, except perhaps on the low terrace lands bordering Ocmulgee River and in the swamps of Little Ocmulgee River in the extreme southeastern part of the county.

It is believed that the water from the deeply buried Cretaceous deposits is softer than that from the overlying Eocene and Oligocene formations.

LOCAL SUPPLIES.

Eastman (population 2,355, census of 1910).—The water-supply system of Eastman is owned by W. E. Davidson. The water is derived from a nonflowing artesian well (No. 5, Table 29) 640 feet deep, in which it rises to within 100 feet of the surface, or about 257 feet above sea level. The water is considered hard but is otherwise suitable for a municipal supply.

McCallie [1] gives the following data on another well at Eastman (No. 4, Table 29):

> The well at Eastman is 529 feet deep. Its diameter is 4 and 6 inches, and the water rises to within 115 feet of the surface. Two or three different water-bearing strata are reported in the well, but the present water supply is said to be obtained from sand 529 feet from the surface. No record of the well borings was kept and nothing is known of the formations penetrated further than that they consist of sand, clay, and hard rock, the latter being most abundant and in places consisting largely of bowlders, which greatly interfered with the drilling. The well, which was put down in 1894, furnishes daily, to supply the town of Eastman, about 30,000 gallons of water.

Chester (population 278, census of 1910).—Dug wells 25 to 35 feet deep are the principal source of water. One artesian well (No. 3,

[1] Georgia Geol. Survey Bull. 15, p. 90, 1908.

Table 29) owned by the Carson Naval Stores Co. is 158 feet deep, 8 inches in diameter, and yields 6,000 gallons of water per hour. The principal flow is from a cavity in limestone at a depth of 158 feet, the water from which rose to within 109 feet of the surface. An analysis of the water is given in Table 30 (analysis 1).

Partial log of well at Chester (No. 3, Table 29).

[Authority, W. J. Floyd, driller.]

	Thickness.	Depth.
	Feet.	*Feet.*
Sand	3	3
Clay	93	96
Lime or sand rock	14.5	110.5
White clay	5.5	116
Lime or sand rock	11.5	127.5
Soft white clay	13.5	141
Hard flint rock, 8 inches thick	.6⅔	141.6⅔
Open cavity, hard limestone at bottom	16.3⅓	158

Chauncey (population 350, census of 1910).—Chauncey is located on the Southern Railway in the southeastern part of the county at an elevation of 300 feet above sea level. Dug wells 15 to 50 feet deep are the principal source of water. McCallie[1] states that one well (No. 1, Table 29) owned by the A. B. Steele Lumber Co. is 525 feet deep and that water rose to within 70 feet of the surface.

Jay Bird Spring.—Jay Bird Spring (No. 2, Table 29), owned by T. A. McMillan, is at the edge of Little Ocmulgee River swamp, 4 miles east of Chauncey. The spring is in reality a shallow flowing well formed by driving a pipe into the earth about 15 feet. The water flows 8 gallons a minute and will rise 8 feet above the surface. The water has a reputed therapeutic value and is used at the spring for drinking and bathing and is also bottled and sold. (See analysis 2, Table 30.)

Wild Rose Mineral Spring.—Wild Rose Mineral Spring is a small spring near Southerland, owned by the Wild Rose Mineral Spring Co. Its water has reputed therapeutic properties and is sold in small quantities for medicinal use. (See analysis 3, Table 30.)

Rhine.—A well at Rhine (No. 6, Table 29), owned by the town, is 150 feet deep. Its curb is about 20 feet above the level of the railroad station. Water stands within 30 feet of the surface but is lowered 30 feet by pumping. It is reported to be muddy in rainy weather.

[1] Georgia Geol. Survey Bull. 15, p. 90, 1908.

TABLE 29.—*Wells in Dodge County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Chauncey	A. B. Steele Lumber Co.	R. J. Edingfield.	S. W. McCallie [a]		+300
2	Jay Bird Spring, 4 miles east of Chauncey.	T. A. McMillan		T. A. McMillan		
3	Chester	Carson Naval Stores Co., Savannah, Ga.	W. J. Floyd, Savannah, Ga.	W. J. Floyd	1910	[b]
4	Eastman	Town		S. W. McCallie [a]	1894	357
5	do	W. E. Davidson				357
6	Rhine	Town				[c]

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	525	6	300		− 70				
2	15				+ 8	8		Flows	Analysis 2, Table 30.
3	158	8	158		−109		100	Deep-well pump	Analysis 1, Table 30.
4	529	4	529		−115		20		
5	640				−100				
6	150	3	±100		− 30		10	Gasoline engine	Hard.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Boiler supply	Eocene?		
2	Drinking and bathing.	Alum Bluff formation?		
3	Domestic	Vicksburg formation.	Cavity in limestone.	8-inch casing to 143 feet. Cost of well $850; cost of machinery, $350. See log, p. 226.
4	do	Eocene?	Sand	
5	do	do		
6	Domestic and boiler supply.	Chattahoochee or Vicksburg formation?	Clay and rock	

[a] Georgia Geol. Survey Bull. 15, p. 90, 1908.
[b] Elevation 12 feet lower than track of Wrightsville & Tennille R. R. at station.
[c] Elevation 20 feet higher than track of Seaboard Air Line Ry. at station.

TABLE 30.—*Analyses of underground waters from Dodge County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	Mar., 1910	Well of Carson Naval Stores Co.	Chester.....	Vicksburg formation.	158	Edgar Everhart.
2	Jan. 13, 1913	Jay Bird Spring (a shallow well).	Chauncey, 4 miles east of.	Alum Bluff formation ?	15	Do.
3	Apr. 8, 1910	Wild Rose Mineral Spring.	Southerland.....	.....do.....	.....	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	28	1.4	35	1.4	2.4	0.5	.....	112	1.3	.....	4.2	.....	132	No. 3, Table 29.
2	21	2.0	56	4.0	14		0.0	210	14	0.0	4.0	.....	211	No. 2, Table 29.
3	5.0	.4	1.3	.5	1.5	.5	.....	36	.2	.....	3.5	.....	17	

DOOLY COUNTY.

GENERAL FEATURES.

Dooly County is in the northwestern part of the Coastal Plain of Georgia, between Flint and Ocmulgee rivers. Vienna, the county seat, is 56 miles by rail south of Macon. The area of the county is 397 square miles and its population is 20,554 (census of 1910). Agriculture is the chief industry. Lumber and naval stores are produced, but these industries are declining.

TOPOGRAPHY.

The surface of Dooly County is nearly level except in the west, where some rolling land has been produced by the erosion of small tributaries of Flint River. Lime sinks and ponds are numerous. The highest part of the county is a belt of country 350 to 400 feet above sea level extending north and south through the center of the county and forming the divide between Flint and Ocmulgee rivers. The Georgia Southern & Florida Railway traverses this divide.

GEOLOGY.

The Vicksburg formation, which consists chiefly of limestones that weather to red argillaceous sands containing fragmental beds of flint, appears at the surface over the greater part of the county west of the Georgia Southern & Florida Railway and in a small area east of that railroad. Its thickness probably does not exceed 100 or 150 feet in the north but increases southward. The formation is an

important aquifer. Fifty to 100 feet of sands and clays, of undetermined age, overlie the Vicksburg formation and constitute the surface deposits in the eastern and southeastern parts of the county.

The Vicksburg formation is believed to be underlain by limestones belonging to the Jackson formation, although this formation has not been certainly identified in either surface outcrops or well borings. Sands and clays with subordinate interbedded layers of sandstone and limestone belonging to the Claiborne group of the Eocene outcrop in the banks of Flint River and extend eastward beneath the Jackson formation; these beds are estimated to be 100 feet or more in thickness. The Claiborne group is probably underlain by Eocene sands and clays belonging to the Wilcox or Midway formations, or to both, and at still greater depths the Eocene deposits are underlain by sands, clays, and marls of Cretaceous age. At an unknown depth, probably between 900 and 1,200 feet, the Cretaceous deposits rest upon a basement of ancient crystalline rocks.

All the formations described, except perhaps the surficial sands and clays, may be considered possible sources of artesian water. The general lithologic character of the strata is indicated by the logs of wells at Byromville (p. 230) and Unadilla (p. 231).

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Wells 30 to 60 feet deep are the principal source of water supply in the rural districts. There are many small springs. Numerous small streams afford abundant water for stock and for boilers. Several wells range in depth from 130 to 1,100 feet.

Artesian waters can be obtained from the Vicksburg formation, or at greater depths from the Eocene and the Cretaceous deposits. Flowing wells can probably be obtained only on the lower lands bordering Flint River and its larger tributaries.

LOCAL SUPPLIES.

Vienna (population 1,564, census of 1910).—The town of Vienna owns a public water-supply system, which draws 800 gallons a minute from an artesian well (No. 8, Table 31) 213 feet deep. The water is used for domestic purposes and for fire protection and to some extent for boiler supplies. McCallie [1] mentions a well at this place 180 feet deep, in which the water rises to within 12 feet of the surface. Some wells are 30 to 60 feet deep.

For the purpose of determining the quality of water from the Vicksburg formation a sample from an artesian well 137½ feet deep (No. 9, Table 31), owned by J. T. McNeese, 5 miles northwest of

[1] Georgia Geol. Survey Bull. 15, p. 96, 1908.

Vienna, was analyzed. (See Table 32, analysis 3.) The water is obtained from hard rock at a depth of 136 feet and rises to within 16 feet of the surface.

Unadilla (population 1,003, census of 1910).—At Unadilla the public water-supply system is owned by the town. McCallie [1] gives the following information regarding the well (No. 7, Table 31) from which it draws:

> The deep well at Unadilla was completed in 1896. It is 3½ inches in diameter and 189 feet deep. The water rises to within 80 feet of the surface. Mr. E. J. Wilson, the well contractor, has furnished the following notes:
>
> *Log of town well at Unadilla.*
>
> | | Feet. |
> |---|---|
> | Red, sandy clays to | 50 |
> | Rock in the form of bowlders to | 66 |
> | Clay to | 150 |
> | Sand interstratified with hard rock to | 189 |
>
> At the depth of 150 feet from the surface the water used in washing out the drill borings disappeared. This was accounted for by the cavernous limestone struck at that point. The only water-bearing stratum occurs near the bottom of the well. Three thousand gallons of water per hour, the capacity of the pump, have been obtained from this well without lowering the static head. The water, which contains hydrogen sulphide, is used for general domestic purposes.

It is believed that the well draws from the Jackson formation. An analysis is given in Table 32 (analysis 2).

The Georgia Southern & Florida Railway owns an artesian well at Unadilla, the water from which is used in the boilers of locomotives.

Byromville (population 300, census of 1910).—The main source of the water supply of Byromville is an artesian well (No. 1, Table 31) which was completed in 1902. The well is 1,100 feet deep, 8 inches in diameter at the top and 5 inches at the bottom, and contains water that rises to within 16 feet of the surface. McCallie [2] gives the following log:

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[1] Georgia Geol. Survey Bull. 15, p. 95, 1908. [2] Idem, pp. 96, 97.

Log of town well at Byromville (No. 1, Table 31).

	Thickness.	Depth.
	Feet.	*Feet.*
Sandy clay	40	40
Red gravel	10	50
White sand	60	110
Coarse sand	23	133
Blue marl	25	158
Sand	37	195
Rock	15	210
Marl	3	213
Sand rock	5	218
Blue marl	5	223
Sand	4	227
Hard rock	3	230
Sand	185	415
Rock	23	438
Sand rock	12	450
Marl and clay	4	454
Blue marl	160	614
Sand and marl	16	630
Lignite and water	15	645
Marl and sand	204	849
Hard sand	70	919
Sand and water	15	934
Marl	76	1,010
Sand	37	1,047
Marl	53	1,100

The well penetrates all the Eocene deposits and enters the underlying Ripley formation of the Cretaceous for probably several hundred feet. The principal water-bearing bed is said to be at 320 feet. An analysis is given in Table 32 (analysis 1).

Pinehurst (population 451, census of 1910).—At Pinehurst an artesian well (No. 4, Table 31) 318 feet deep is the principal source of domestic supply. The water rises to within 8 feet of the surface.

The Georgia Southern & Florida Railway Co. owns an artesian well at Pinehurst but has abandoned it.

Richwood.—Richwood obtains its water supplies from dug wells 20 to 30 feet deep and from artesian wells. McCallie [1] says:

> The Parrott Lumber Co. some years ago put down two deep wells at Richwood to obtain water for steam and general domestic purposes [No. 5, Table 31]. These wells are 6 inches in diameter and 170 feet deep. The first water-bearing stratum is said to have been struck in the wells at a depth of 85 or 95 feet, but the main water supply was obtained from a stratum at a depth of from 130 to 170 feet, from which the water rose to within 40 feet of the surface. During the time the Parrott Lumber Co. was operating its plant at Richwood these wells are reported to have furnished about 75,000 gallons of water daily. Long droughts are said not to have materially lowered the static head of the water in either of these wells. Hard rock is reported from 60 feet to the bottom of these wells.
>
> A third well at Richwood [No. 6, Table 31], owned by Mr. H. R. Teal, has a depth of 100 feet. It is 4 inches in diameter, and the water rises to within about 35 feet of the surface. Mr. Teal gives the following record of his well:

[*Log of well of H. R. Teal, at Richwood.*]

	Feet.
Clay with some sand	to 90
Limestone	to 96
Sand, water-bearing	to 100

[1] Georgia Geol. Survey Bull. 15, pp. 94, 95, 1908.

Dooling.—Wells 8 to 60 feet deep are the principal source of water for domestic use at Dooling. In one artesian well 600 feet deep (No. 2, Table 31), the water rises to within a few feet of the surface and is said to be ferruginous. The mouth of the well is about 4 feet lower than the surface at the railroad station.

TABLE 31.—*Wells in Dooly County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Byromville	Town		W. E. Dawson	1902	290?
2	Dooling			A. English	1908	266
3	Fenn	Ensign Lumber Co.		S. W. McCallie[a]	1891	
4	Pinehurst			do		390
5	Richwood	Parrott Lumber Co.		do		358
6	do	H. R. Teal		do		358
7	Unadilla	Town	E. J. Wilson	do	1896	412
8	Vienna	do	Mr. Van Fleet	D. L. Henderson, mayor.	1895	350
9	Vienna (5 miles northwest of).	J. T. McNeese	Cole & Hagsett		1910	350

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Level of water below surface.	Yield per minute by pumping.	How obtained.	Quality.
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Galls.*		
1	1,100	5	320	16	2,300?		Analysis 1, Table 32.
2	600		600			Gasoline engine	Ferruginous.
3	160	8		20			
4	318			8			
5	170	6	130–170	40	100		
6	100	4		35			
7	189	3½	189	80	50		Analysis 2, Table 32.
8	213	6	200	12	800	Air-lift pump	Hard.
9	137½	3	136	16	13½	Force pump	Analysis 3, Table 32.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic and manufacturing.	Eocene?	Gravel	Cost of well, $1,000; cost of machinery, $500. See log, p. 231.
2	Domestic	Ripley formation?		Cost of well, $800; cost of machinery, $250.
3				
4		Eocene		
5		Vicksburg formation.		2 wells. Another water-bearing bed at a depth of 85 (or 95) feet.
6		do		See log, p. 231.
7	Domestic	Jackson formation?		Do.
8	Domestic and manufacturing.	Vicksburg formation?	Sand	Cost of well, $400; cost of machinery, $1,500.
9	Domestic	Vicksburg formation.	Hard rock	3-inch casing to 85 feet.

[a] Georgia Geol. Survey Bull. 15, pp. 94–97, 1908.

TABLE 32.—*Analyses of underground waters from Dooly County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	May 30, 1911	Town well.....	Byromville.....	Eocene?	320	E. Everhart.
2	June 5, 1911	.....do.....	Unadilla.....	Jackson formation?	189	Do.
3	July 10, 1911	Well of J. T. McNeese.	Vienna (5 miles northwest of).	Vicksburg formation.	136–137.5	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Remarks.
1	22	0.2	24	12	8.0	0.0	88	20	0.1	15	137	No. 1, Table 31.
2	16	1.0	45	1.0	5.0	.0	158	7.0	.2	3.5	134	No. 7, Table 31.
3	20	Tr.	48	8.0	6.0	.0	170	3.0	.1	5.0	181	No. 9, Table 31.

DOUGHERTY COUNTY.

GENERAL FEATURES.

Dougherty County is in the southwestern part of the Coastal Plain of Georgia. Albany, the county seat, is 100 miles by rail southwest of Macon and 88 miles southeast of Columbus. The area of the county is 342 square miles and the population (census of 1910) is 16,035. Dougherty County is a rich agricultural district; cotton, corn, melons, and fruit are the principal products. The county is also the center of the pecan-growing industry of the State. At Albany there are large fertilizer factories, a cotton-cloth mill, cottonseed-oil mills, an ice factory, and a brick plant. The production of lumber and naval stores is important.

TOPOGRAPHY.

Topographically the county may be divided into two parts. West of Flint River, which flows southward through the eastern part of the county, the general surface is nearly level and is typical of the physiographic division known as the Dougherty plain. This area is closely underlain by the limestones of the Vicksburg formation, and as a result of underground solution and the collapse of solution caverns, the otherwise nearly level surface is dotted with lime-sink depressions (some of which support a growth of cypress), which appear as ponds, as chains of sinks, and as long sinuous depressions. Creeks and small branch streams are few in number and the drainage is partly effected by underground streams through the lime sinks. Coolewahee, Kiokee, and Chickasawhatchee creeks, in the western

part of the county, have very shallow valleys and flow sluggishly through wide swamps. The Dougherty plain west of Flint River is probably 225 to 260 feet above sea level, and the swamps and streams of the same area are thought to be 175 to 200 feet above the same datum plane.

East of Flint River, except a narrow area along the river, the surface is rolling and is typical of the physiographic division described in this report as the Altamaha upland and locally known as the long-leaf pine or wire-grass region. The general upland here is probably 300 feet above sea level. The surface materials consist chiefly of sands and clays residual from the Vicksburg, Chattahoochee, and Alum Bluff formations.

Flint River is bordered by two narrow, nearly level, Pleistocene terrace plains. The elevation of the bed of the river at the crossing of the Central of Georgia Railway at Albany is 127 feet. The lower plain lies about 20 feet above the stream bed, and the higher plain, on which the greater part of the city is located, lies about 60 feet above the same datum plane. The elevation at the Union Station, which is on the higher plain, is 184 feet above sea level.

GEOLOGY.

The Vicksburg formation appears at the surface over all but a relatively small area in the eastern part of the county and is an important aquifer. The formation, which consists of 150 to 200 feet or more of white limestones interbedded with sands and clays, weathers to red argillaceous sands and clays containing fragments of flint. In the eastern part of the county the Vicksburg formation is overlain by the Chattahoochee formation, which consists of sandy limestone and calcareous sands and clays, probably less than 100 feet thick, and which weathers to sands and clays that outcrop in a belt a few miles wide extending east of north through the county. The Chattahoochee formation is overlain by less than 100 feet of greenish-drab sands and clays belonging to the Alum Bluff formation, which outcrops in a relatively small area in the southeast corner of the county. The Vicksburg formation is underlain by 200 or 300 feet of Eocene water-bearing sands, clays, and marls, in interbedded, thin, indurated layers which do not appear at the surface within the county. The Eocene deposits are underlain by the Ripley formation of the Upper Cretaceous, which consists of calcareous and glauconitic sands, clays, and marls, probably aggregating a thickness of 800 feet or more and which contain water-bearing beds. At Albany, the Ripley formation is first encountered in wells at a depth of 500 feet, the deepest well (1,320 feet) probably ending near the base of the terrane. The Ripley formation is underlain by undifferentiated deposits of Cretaceous age which, at an unknown depth, probably

between 2,000 and 3,000 feet, rest upon a basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

In the rural districts water for domestic use is obtained from dug wells 20 to 60 feet deep and from drilled wells 75 to 150 feet deep. The source of the water in both types of well is limestone of the Vicksburg formation, which is cavernous and contains large quantities of water. Some of the dug wells fail during times of drought. Wells less than 100 feet deep are apt to be contaminated from surface sources.

Deep wells have been drilled at Albany, Kioka Place (10 miles southwest of Albany), Ducker station, Putney, Pretoria, and near Walker station.

Small seepage springs are scattered throughout the county and a few limestone springs emit bold streams, but as a whole the springs are not important. Blue Spring, the largest in the county, is described on page 240. The waters of ponds and streams are used locally for stock and in boilers.

Artesian water can be obtained anywhere in the county at depths of 75 to 1,500 feet or more. The prospects are good for obtaining flows from Eocene strata on the terrace plains bordering Flint River and in the valleys of the small streams in the western part of the county. The deeply buried Cretaceous deposits will probably yield flows throughout the greater part of the county west of Flint River.

LOCAL SUPPLIES.

Albany (population 8,190, census of 1910).—Three artesian wells furnish the public water supply at Albany, and 12 or 15 others are owned by individuals or companies in and near the city. Four principal artesian water-bearing beds are tapped: The first is at depths of 300 feet or less in cavities or beds of sand in the Vicksburg formation; the second is between the depths 660 and 710 feet, probably in the Ripley formation; the third is between the depths 840 and 900 feet in the Ripley formation; the fourth is between the depths 1,310 and 1,320 feet in the Upper Cretaceous and probably in the Ripley formation. The municipal wells are at the pumping station, 218–222 North Street, where the elevation above Flint River is estimated to be 60 feet. Well No. 1 is 750 feet deep, well No. 2 is 1,320 feet deep, and well No. 3 is 940 feet deep. Originally all three wells flowed but now only No. 2 does so. Nos. 1 and 3 are pumped by air lift, each yielding 450 gallons per minute. In well No. 1 the water is lowered 90 feet by continuous pumping, and as the well is old it is thought that some water is lost through leaks in the casing.

The following log of city well No. 2 was furnished by C. W. Tift.[1] The attempted correlations are based on the fossils obtained from the well and determined, except as otherwise indicated, by T. W. Vaughan.

Log of city artesian well No. 2, Albany (No. 2, Table 33).

	Feet.	
Tertiary:		
Red clay	0–	20
Light-colored clay	20–	23
Coarse sand (Vicksburg)	23–	25
Light-colored clay and coarse quartz sand	25–	35
Limestone, Orbitoides sp. at 150 feet, and from 190 to 200 feet	35–	200
Gray limestone, Orbitoides sp., echinoid, Bryozoa, *Terebratulina lachryma* Morton (identified by W. H. Dall), some shale from 230 to 240 feet	200–	280
Gray sand with comminuted shells (Ostrea)	280–	285
Some shale, coarse sand, shells, and sharks' teeth at		311
Hard layer, *Ostrea divaricata* Lea	318–	320
Ostrea divaricata Lea at		330
Ostrea alabamiensis Lea at		340
Shale or marl, water vein at		350
Ostrea divaricata Lea and *Ostrea alabamiensis* Lea at		363
Bed of lignite at		367
Bed of lignite at		400
Sand	400–	470
Stiff blue clay, echinoid spines, Lamna sp. (teeth)	470–	475
Stiff blue clay	475–	480
Hard gray sandstone	485–	488
Upper Cretaceous, Ripley formation:		
Ostrea sp. and *Exogyra costata* Say (?)	500–	510
Pyrite and small oysters at		520
Greensands and greenish micaceous shales	530–	540
Gray sands with black particles at		600
Water-bearing horizon, limestone, with pieces of hard gray sandstone between 785 and 790 feet	690–	790
Hard rock	790–	800
Clay shales, white limestone between 835 and 840 feet	800–	850
Limestone, shales, etc; at 880 feet limestone or calcareous sand, also light-gray micaceous sand	850–	890
Grayish sand, calcareous fragments, hard black pieces of pebbles, Ostrea sp., *Anomia argentaria* Morton. [*Gryphæa vesicularis* Lamarck (young)] at 890 feet; water-bearing, micaceous sandstone between 920 and 930 feet	890–	940
Blue micaceous clay at 950 feet, thick-shelled oyster, Gryphæa sp., the same also at 1,080 feet; at 1,100 feet gray sand with *Ostrea subspatulata* Forbes, *Exogyra costata* Say	940–	1,100
Stiff blue clay, micaceous sandstone, *Ostrea cretacea* Morton (?)	1,100–	1,200
Very stiff blue clay at 1,255 feet, streaks of sand and shells, a small flow of water; from 1,240 to 1,260, soft shiny blue clay	1,200–	1,260
Marl, gray sand, sandstone lumps, shells	1,260–	1,270
Gray and black sand, sandstone lumps	1,270–	1,310
Black, irregular, water-worn pebbles, with hard crystalline fracture; coarse and fine quartz sand, shells, decayed wood, fourth water-bearing stratum; 50 gallons per minute	1,310–	1,315
Well ends in quartz sand at		1,320

[1] Georgia Geol. Survey Bull. 15, pp. 98, 99, 1908.

A sample of material taken from 1,300 to 1,315 feet in the well just described consists of light-gray, medium-grained very micaceous (muscovite) sand, with numerous fragments of dark irregular glauconitic sandstone, some partly water worn; several angular fragments of gray calcareous sandstone; numerous fragments of lignite and shells of invertebrates. The following species were identified by Mr. Stephenson:

Vermes:
- Hamulus major Gabb.

Molluscoidea:
- Fragment of poorly preserved Bryozoa.

Mollusca:
- Ostrea larva Lamarck.
- Ostrea sp. (irregular form).
- Gryphæa vomer (Morton).
- Exogyra ponderosa Roemer.
- Pecten quinquecostatus (Sowerby).
- Plicatula sp.
- Fragments of undetermined gastropods and pelecypods.

In terms of the Chattahoochee River section the fossils listed indicate that the containing strata correspond in position to beds low in the Ripley formation.

A public flowing well known as the Coffey well, not connected with the pumping station, is at 201 Commerce Street. It was originally 715 feet deep but was later drilled to a depth of 840 feet. The water is used for drinking and domestic purposes. It rises 10 feet above the surface and flows 40 gallons a minute. It is soft, clear, and palatable but emits an odor of hydrogen sulphide. (See analysis 3, Table 34.) According to Mr. Tift the water comes from a stratum tapped at the bottom of the well and is therefore from the Ripley formation.

Spencer [1] gives the following data concerning a well at Albany (name of owner not stated):

Several wells have been sunk at Albany and flowing water has been obtained. The record of one of these was furnished by Mr. Charles Tift, and also samples of borings from several depths. This well has an elevation of about 20 feet above the railway station:

[*Log of well at Albany (No. 7, Table 33).*]

	Feet.
Surface soil and red clay to	23
Light clay, white sand, colored clays, and white lime rock to	55
Flinty rock to	60
Limestone with clay seams to	315
Thick rock to	319
Quicksand with a rocky stratum at 440 feet, and lignite just above rock, to	480
Black sand—thin layer.	
Blue marl strata to	678
Porous water-bearing beds to	732

[1] Spencer, J. W., Georgia Geol. Survey First Rept. Progress, pp. 75–77, 1891.

Samples were taken and examined as follows: Marl at 26 feet; limestone at 40 feet; oolitic or coral sand from 110 to 115 feet; a lime rock, 5 feet thick, at 160; gray rotten limestone from 180 to 200; shell rock at 310; shell marl at 315 to 320; lignite at 340; coarse quartz sand with chips of gray limestone, 350; shell limestone, 360; clean sharp white sand in different beds between 360 and 425; lignite at 440; green, slightly calcareous fine sand, with a little clay between, 485 and 678; a water-bearing coarse quartz sand, with calcareous particles, at 660.

Through T. W. Vaughan Mr. C. W. Tift has also furnished what seems to be another log of the same well (No. 7, Table 33):

Log of well owned by Nelson Tift, Albany (No. 7, Table 33).

	Thickness.	Depth.
	Feet.	*Feet.*
Surface soil	2	2
Red clay	23	25
Coarse white sand	5	30
Black and brown clays	10	40
White limestone	15	55
Flinty rock	5	60
Limestone with interbedded seams of clay	256	316
Hard rock	4	320
Quartz sand with several harder layers in upper 20 feet; shells at 225 feet; thin, hard layer at 440 feet	160	480
Blue marl; layer of black sand 6 feet below top	198	678
Porous layer of shells and gravel	54	732

Mr. Tift has furnished the following information concerning the artesian well at the ice factory of the Atlantic Ice & Coal Co.: The well was bored in 1885 and is 710 feet deep; it was recased to 660 feet in 1901. At a depth of 320 feet water was encountered, which rose to within 42 feet of the surface and this static head was maintained until the water-bearing stratum at 660 feet was reached, when the static head rose to 26 feet above the surface. The amount of the flow has since greatly decreased and the static head is thought to have been affected by a well 708 feet deep, completed in 1910, at the Albany Cotton Mills, a mile north of the ice factory. The principal water-bearing stratum in the Albany Cotton Mills well is between the depths of 680 and 708 feet.

Log of well owned by the Atlantic Ice & Coal Co. (No. 6, Table 33).

	Thickness.	Depth.
	Feet.	*Feet.*
Red clay	30	30
Limestone	80	110
Sand	7	117
Limestone with layers of sand	33	150
Limestone with clay seams	150	300
Shell marl, oyster shells	20	320
Pure quartz sand	112	432
Principally blue marl (calcareous clay) flow begins	228	660
Porous cellular water-bearing rock, limestone	50	710

Kioka Place.—A 725-foot flowing well (No. 8, Table 33) known as the Williams irrigation well, located at Kioka Place (10 miles southwest of Albany), is owned by Mr. John P. Fort, of Albany. The well was completed in 1911 and is used for the irrigation of 14 acres of land planted to onions, corn, and cotton. It yields 40,000 gallons of water a day, which is stored for distribution in an earthen reservoir holding 400,000 gallons. Mr. Fort states that the returns on the 14 acres have been exceptionally large, the yield of corn being estimated at 200 bushels per acre, and he thus demonstrates the possibilities of irrigation in the areas of flowing wells in Georgia. Mr. Fort has furnished the following log, which is a carefully prepared record of the materials penetrated as drilling progressed:

Log of Williams irrigation well at Kioka Place, 10 miles southwest of Albany (No. 8, Table 33).

	Thickness.	Depth.
	Feet.	*Feet.*
Red clay	4	4
Red sand	26	30
White chalky material	10	40
Red sand	30	70
Red sand, water bearing	5	75
Cream-colored limestone	77	152
Blue "soapstone" (shaly clay?)	20	172
Blue sandstone	23	195
Flint	6	201
Blue sand	27	228
Flint	24	252
Sand	26	278
Rock	1	279
Rock and sand	14	293
Blue marl	8	301
Sand and soft sandstone	43	344
Very hard rock	10	354
Hard to soft rock	6	360
Blue marl	30	390
Blue "soapstone" (shaly clay?)	1	391
Blue marl	30	421
Blue "soapstone" (shaly clay?)	1	422
Blue marl	37	459
Hard sandstone	16	475
Fine green sand	20	495
Sand, marl, and rock	2	497
Sand and rock, water bearing; flows 2 gallons a minute	3	500
Sandstone, marl, and rock, water bearing	47	547
White milky rock; at this depth the water flows 6 gallons a minute	12	559
Hard white milky rock, water bearing; flows 15 gallons a minute	20	579
White grayish rock, water bearing; flows 20 gallons a minute	21	600
Grayish sandstone with black grains and shells, poorly water bearing; water flows 25 gallons a minute	80	680
Grayish rock and indurated blue marl, water bearing; water flows 50 gallons a minute	15	695
Grayish, water-bearing rock and indurated blue marl; water flows 60 gallons a minute	30	725

A 6-inch casing extends to 80 feet; 4½-inch casing to 277 feet; 3½-inch casing to 120 feet and from 371 to 444 feet; 2½-inch casing from 120 to 500 feet.

The well starts in the Vicksburg formation and probably penetrates that terrane to at least 152 feet, beyond which to 725 feet it probably penetrates Eocene strata doubtless belonging to several formations. However, it may enter the upper part of the Ripley formation of the Upper Cretaceous.

Ducker station.—The first flowing well in Georgia was drilled near Ducker station, 16 miles west of Albany, by J. P. Fort, in 1881. It is 547 feet deep and flows 10 feet above the surface. Spencer[1] gives the following log:

Log of well of John P. Fort at Ducker station (No. 9, Table 33).

	Thickness.	Depth.
	Feet.	*Feet.*
A few feet of surface clay, followed by limestone bowlders	65	65
Limestone with silicified layers containing shells and traversed by subterranean streams	85	150
Blue marl (clay?)	15	165
Shell rock, sand rock, and marl (clay); water rose to within 14 feet of surface	95	260
Sand, tinted blue; layer of very fine white sand at 370 feet, below which some coarse sand with shell fragments and sharks' teeth	120	380
Blue clay and sand rock in alternate layers	30	410
Blue clay with soft sand rock to flowing water	80	490
Sand and clay, forming water-bearing stratum	40	530
Hard rock (thickness not reported)	17	547

At Ducker station artesian water has recently been used for irrigation.

Putney.—From Putney (Hardaway station), on the Atlantic Coast Line Railroad just east of Flint River, 8 miles south of Albany, one well owned by F. F. Putney has been reported. The depth of the well is about 315 feet, and the water in it rises to within 50 feet of the surface. It is probable that by deeper drilling flowing wells can be obtained at this place, for the elevation is only 183 feet above sea level.

Pretoria (population 369, census of 1910).—At Pretoria two artesian wells supply the village with water for all purposes. One well is 650 feet deep and flows, the static head being 12 feet above the surface. The other well is 350 feet deep and does not flow. The water is distributed from a tank.

Blue Spring.—Blue Spring, 4 miles south of Albany, on the east side of Flint River, and about 300 yards back from the river bank, is believed to be the largest spring in the State. (See Pl. XX, *A*.) Discharge measurements made at different times[2] show yields ranging from 26.4 to 135 second-feet, or approximately 18,000,000 to 87,000,000 gallons every 24 hours. The water, which rises under considerable pressure from several small openings in limestone of the Vicksburg formation and has a faint bluish tinge, is very clear and is said to remain clear, although the supply varies with the rainfall. The main spring is 20 or 30 feet deep, and the temperature of the water is 69° F. An analysis of the water is given in Table 34 (analysis 5). The water is used locally for drinking.

[1] Spencer, J. W., Georgia Geol. Survey First Rept. Progress, p. 77, 1891.

[2] Hall, B. M. and M. R., Water resources of Georgia: U. S. Geol. Survey Water-Supply Paper 197, p. 236, 1907.

A. STREAM FLOWING FROM BLUE SPRING, 4 MILES SOUTH OF ALBANY, DOUGHERTY COUNTY.

Yields more than 18,000,000 gallons a day. Photograph by S. W. McCallie.

B. PUBLIC FOUNTAIN AT AMERICUS, SUMTER COUNTY.

Photograph by S. W. McCallie.

TABLE 33.—*Wells in Dougherty County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Albany (well No. 1 at pumping station).	City		C. W. Tift	1892	184
2	Albany (well No. 2 at pumping station).	do	E. F. Joyce	do	1904–1906	184
3	Albany (well No. 3 at pumping station).	do	C. E. Edwards	C. E. Edwards and C. W. Tift.	1907	184
4	Albany, 201 Commerce Street, 1½ miles north of city water-supply plant.	do		C. M. Clark	1903	210
5	Albany	Albany Cotton Mills.	M. B. Matthews.	M. A. Jarrard	1910	
6	do	Atlantic Ice & Coal Co.		C. W. Tift	1885, 1901	
7	do	Nelson Tift	C. W. Tift	do	1885	
8	Kioka Place, 10 miles southwest of Albany.	John P. Fort	Owner	Owner	1911	
9	Ducker station	do		S. W. McCallie[a]	1881	
10	Putney (Hardaway station).	F. F. Putney		do		183
11	Pretoria			W. A. Bierman		
12	do			do		
13	do	Red Cypress Lumber Co.		S. W. McCallie[a]	1902	
14	Walker station (1 mile north of).	H. J. Lamar		do		

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute. Flow.	Yield per minute. Pump.	How obtained.	Quality.
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	750	10	680		+10		450	Air-lift pump	
2	1,320	12	660–710	300; 840–900; 1,320	+20	125		Flows	Analyses 1, 2, Table 34.
3	940	10	680		+ 8	80	450	Air-lift pump	
4	840	6			+10	40		Flows	Analysis 3, Table 34.
5	708	3½	680–708	180		100		do	
6	710		660	320	+26			do	Analysis 4, Table 34.
7	732	4	678				105	do	
8	725	2½	500–725			28		do	Soft.
9	547	2			+10			do	
10	315	6			−50				
11	350				−16				Slightly alkaline.
12	650				+12	35		Flows	Do.
13	585	4½	580–585?	375				do	
14	146	4			−35				Sulphurous.

[a] Georgia Geol. Survey Bull. 15, pp. 101–103, 1908.

TABLE 33.—*Wells in Dougherty County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Municipal supply.	Ripley formation..	Porous rock.....	10-inch casing to 680 feet.
2	.....do.....	.....do.....	Porous sandstone.	Cased to 1,300 feet. See log, p. 236.
3	.....do.....	.....do.....	Porous rock.....	8-inch casing to 710 feet. Cost of well, $4,000.
4	Domestic.....	.....do.....	.....	"Coffey" well.
5	.....do.....	.....do.....	White, porous rock	3½-inch casing to 480 feet.
6	.....	.....do.....	.....	Cased to 660 feet. See log, p. 238.
7	.....	.....do.....	Gravel and shells..	See logs, pp. 237, 238.
8	Irrigation.....	Eocene.....	Sand, limestone, and marl.	Cost of well, $2,500. Caving sand has reduced yield from 60 to 30 gallons a minute. See log, p. 239.
9	.....do.....	Midway formation?	.....	See log, p. 240.
10	.....	Vicksburg formation.	.....	
11	Domestic.....	Eocene?.....	.....	
12	.....do.....	.....do.....	.....	
13	.....	Eocene.....	.....	
14	.....	Vicksburg formation.	.....	

TABLE 34.—*Analyses of underground waters from Dougherty County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	.....	City well No. 2..	Albany.....	Ripley formation.	660–710	H. C. White.[a]
2	.....	.....do.....	.....do.....	.....do.....	1,320	Edgar Everhart.[a]
3	June 10, 1911	"Coffey" well; now owned by the city.	Albany, 201 Commerce Street.	.....do.....	840	Do.
4	Apr. 1, 1911	Well of Atlantic Ice & Coal Co.	Albany.....	.....do.....	660–710	Do.
5	.....do.....	Blue Spring.....	Albany, 4 miles south.	Vicksburg formation.	20–30	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	9.3	[b] 2.6	46	1.9	2.4		.....	140	7.1	0.2	3.6	7.8	160	From water-bearing stratum at 660–710 feet, No. 2, Table 33.
2	14	[b] 1.8	4.3	1.8	463	29	576	.....	1.4	.....	69	.....	1,159	From water-bearing stratum at 1,320 feet, No. 2, Table 33. A trace of PO_4.
3	22	4.0	5.0	3.0	60		7.0	160	25	.4	4.0	.....	174	No. 4, Table 33.
4	16	1.0	13	6.8	41		.0	178	14	1.2	3.5	.....	193	No. 6, Table 33.
5	12	.4	49	2.4	3.8		.0	178	2.0	1.5	3.5	.....	139	

[a] Georgia Geol. Survey Bull. 15, pp. 99–100, 1908.

[b] $Fe_2O_3+Al_2O_3$.

EARLY COUNTY.

GENERAL FEATURES.

Early County is in the southwestern part of the Coastal Plain of Georgia, adjacent to Alabama. Its area is 524 square miles and its population 18,122 (census of 1910). Cotton, corn, lumber, and naval stores are the chief products.

TOPOGRAPHY.

The county presents two types of topography. The eastern three-fourths falls within the physiographic division known as the Dougherty plain; its surface is nearly level to gently undulating; streams are few in number and flow through wide swampy bottoms, and it has many cypress ponds. The Dougherty plain, which is approximately coextensive with the surface occurrence of the Vicksburg formation, is well developed in the adjoining counties of Calhoun, Baker, Miller, and Decatur.

In the western part of the county, and particularly in the northwest, the surface is hilly. Chattahoochee River, which forms the western boundary, has cut its valley 150 to 200 feet lower than the general upland. Small tributary streams, which enter from the east, have cut deep narrow valleys, thus producing a broken topography which extends 5 to 6 miles back from the river.

Chattahoochee River is bordered by two Pleistocene terraces; the lower (Satilla plain) is nearly level, is about one-half mile wide, and lies about 40 feet above the river; the upper (Okefenokee plain) lies about 100 feet above the river and is not so well preserved as the lower. Unlike the other large rivers of the Coastal Plain of Georgia the Chattahoochee is bordered by few swamps.

At the station of the United States Weather Bureau at Blakely the elevation is 300 feet above sea level. Exact determinations of level have not been made elsewhere in the county, but it is probable that the greater part of the area is less than 300 feet above sea level.

GEOLOGY.

The Vicksburg formation outcrops in an area approximately coextensive with that of the Dougherty plain. It consists of interbedded limestones and sands which weather to red or mottled argillaceous sands and clays containing masses of flint. The unweathered limestones generally lie 50 feet or less below the surface and outcrop at a few places. The thickness of the formation is believed to be 75 to 150 feet in the north, but it increases to the east and south and probably reaches a maximum of 250 or 300 feet. The formation is an important aquifer.

The Jackson formation, which consists principally of soft limestones of relatively small thickness, underlies the Vicksburg formation and in the southwest outcrops in a small area bordering Chattahoochee River. The Jackson formation, and the Vicksburg where the Jackson is absent, is underlain by the Claiborne group of the Eocene. The Claiborne group consists of 200 to 250 feet of sandy marls with subordinate thin interbedded layers of hard sandy limestone and glauconitic calcareous sandstone overlain by red and varicolored sands with subordinate thin interbedded layers of clay. These beds immediately underlie the surface in the western part of the county and are well exposed in the bluffs of Chattahoochee River. They probably include representatives of the McBean formation and the Barnwell sand, into which the group has been subdivided elsewhere in the State. The group contains water-bearing beds.

The Claiborne group is underlain by an undetermined thickness of undifferentiated Eocene deposits which do not reach the surface within the county. The Eocene is underlain by 800 or 900 feet of more or less calcareous and glauconitic sands, clays, and marls that contain water-bearing beds and are referable to the Ripley formation of the Upper Cretaceous. In the deep well at Blakely fossils of Ripley age were first encountered at a depth of 500 feet. The Ripley formation is underlain by undifferentiated Cretaceous deposits of unknown thickness, and at some undetermined depth, probably between 2,000 and 3,000 feet, the Cretaceous deposits rest upon a basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Water for domestic use is supplied chiefly by dug and bored wells 20 to 75 feet deep. In the western part of the county bored wells should be preferred to dug wells, for if properly cased they are less likely to be contaminated by surface water.

Small springs are scattered throughout the county and are a source of domestic supply. Cedar Spring, one-half mile east of Cedar Springs post office, is reported to yield about 80 gallons a minute of soft water, which is used for general domestic purposes and in the condensers at a turpentine distillery.

Artesian water can probably be obtained anywhere in the county. Water-bearing beds occur in the Vicksburg formation and also in the underlying Eocene and Cretaceous sands and marls. Waters from the Cretaceous deposits are apt to be softer than those from the Vicksburg formation.

In wells on the lowest terrace bordering Chattahoochee River waters from Eocene or Cretaceous strata will probably flow. This is

probably true also of wells 600 feet or more in depth in the valleys of some of the larger creeks, although this remains to be tested.

LOCAL SUPPLIES.

Blakely (population 1,838, census of 1910).—Blakely owns a municipal water-supply system and obtains water from a well 812 feet deep (No. 3, Table 35). T. W. Vaughan obtained notes and well borings from the driller, S. S. Chandler, from which the following description and partial log were prepared:

The well was completed in 1902 at a cost of $3,000; the diameter at the top is 10 inches and at the bottom 6 inches. Water-bearing beds were encountered at depths of 250, 570, and 812 feet. The municipal supply is taken from the 812-foot level, the water from which rises to within 19 feet of the surface and is not lowered perceptibly when pumped 290 gallons a minute.

Partial log of town well at Blakely (No. 3, Table 35).

	Thickness.	Depth.
	Feet.	*Feet.*
Red sandy clay	10	10
Coarse grayish sand	10	20
Coarse light-yellowish sand	10	30
Yellowish cherty limestone (Vicksburg)	10	40
Yellowish or grayish sandstone	10	50
Light-colored, almost white, calcareous sandstone	20	70
Gray sands, darker at bottom	70	140
Greenish sands, with *Ostrea divaricata* Lea	20	160
Fine gray sand, hard ledge at bottom, water bearing at a depth of 250 feet	125	285
Fine sand; some clay	5	290
Bluish clay	200	490
Quartz sand, with glauconite	10	500
Hard sandstone, with glauconite. Two oysters, apparently Gryphæa sp. and *Exogyra costata* Say (Ripley formation)	10	510
Grayish or bluish sands, water bearing at a depth of 570 feet	70	580

From 580 feet to the bottom of the well the beds encountered are said to have been limestones interstratified with sands and clays, the water-bearing bed at 812 feet being a coarse sand. Fossils of Ripley (Cretaceous) age were identified from the sandstone at 500 to 510 feet. An analysis is given in Table 36 (analysis 1).

An artesian well (No. 4, Table 35) owned by the Callahan-Powell Co., 6½ miles east of Blakely, is 485 feet deep and contains water that rises to within 50 feet of the surface. The elevation of the well above sea level is reported to be 250 feet. The water-bearing bed is probably in the Midway formation of the Eocene. An analysis of the water is given in Table 36 (analysis 2).

Damascus.—Damascus obtains water for domestic use chiefly from wells 20 to 60 feet deep. The deeper wells yield hard water and probably reach the unweathered limestone of the Vicksburg formation. Notes on a deep well (No. 6, Table 35) at this place are given by McCallie.[1]

[1] Georgia Geol. Survey Bull. 15, p. 107, 1908.

Mr. C. C. Green's well at Damascus is 2 inches in diameter and 547 feet deep. Considerable hard rock is reported in this well, but the exact thickness and character of the various formations were not ascertained. Two water-bearing strata were struck in the well, one at 200 and the other at 547 feet. Water from the former rises to within 20 feet of the surface, and from the latter to within 7 feet of the surface. Both strata are said to furnish a good supply of water.

Cowarts station.[1]—The following log of a well (No. 5, Table 35) 120 feet deep at Cowarts station has been furnished by W. R. Carter, the owner.

Log of W. R. Carter's well, Cowarts station (No. 5, Table 35).

	Thickness.	Depth.
	Feet.	*Feet.*
Reddish clay	30	30
Sand	2	32
Limestone; water from 7-foot cavity struck at depth of 113 feet, rose immediately to within 27 feet of the surface	88	120

Other localities.—A well (No. 1, Table 35) on the plantation of H. G. Smith, 6 miles west of Arlington, is 160 feet deep. The principal water-bearing bed is limestone at 160 feet. The water rises to within 12 feet of the surface and is used for general domestic purposes.

A well (No. 2, Table 35) on the plantation of James Johnson, 3 miles south of Arlington, is 360 feet deep and 2½ inches in diameter. According to the driller it penetrated little hard rock. The well yields an abundance of water sufficient for the needs of a large plantation.

At Saffold, in the southwestern part of the county, nonflowing wells from 350 to 490 feet deep are reported.

TABLE 35.—*Wells in Early County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Arlington, 6 miles west of.	H. G. Smith	J. G. Chason	J. G. Chason	1910	(a)
2	Arlington, 3 miles south of.	James Johnson	M. A. Jarrard	M. A. Jarrard		
3	Blakely	Town	S. S. Chandler	S. S. Chandler[b]	1902	300
4	Blakely, 6½ miles east of.	Callahan-Powell Co.		W. A. Kitchen	1903	250
5	Cowarts station (Kara).	W. R. Carter		S. W. McCallie[b]	1897	
6	Damascus	C. C. Green		do		
7	Hilton			Postmaster		
8	Jakin	Flowers Lumber Co.		do		
9	Saffold			do		105

[a] Elevation 20 or 30 feet above the bed of Spring Creek.
[b] Georgia Geol. Survey Bull. 15, pp. 105–107, 1908.

[1] McCallie, S. W., loc. cit.

TABLE 35.—*Wells in Early County*—Continued.

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	160	4½	140–160	.....	12	.....	.....	Hand pump.....	Slightly sulphurous.
2	360	2½	.....	.....	.....	.....	.....	Pump.....	
3	812	6	812	250, 570	19	.....	290	.....	Analysis 1, Table 36.
4	485	4	.....	.....	50	.....	.....	Gasoline engine, deep-well pump.	Analysis 2, Table 36.
5	120	4	113	.....	27	.....	.....	.....	
6	547	2	547	200	7	.....	.....	.....	Good.
7	75	.....	.....	.....	.....	.....	.....	Pump.....	Hard.
8	190	.....	.....	.....	40	.....	.....	.....	Do.
9	490	.....	.....	.....	.....	.....	.....	Pump.....	Slightly sulphurous.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic.....	Vicksburg formation?	Marl.....	
2	Plantation use....	Eocene?.....	.....	
3	Municipal supply.	Ripley formation..	.....	See log, p. 245.
4	Domestic.....	Eocene; Midway formation?.....	Sand..... .....do.....	
5	.....	Vicksburg formation.	.....	Limestone cavity at 113 feet. See log, p. 246.
6	.....	Eocene?.....	.....	
7	.....	.....do.....	.....	
8	Domestic, boiler supply.	Vicksburg formation.	Rock	
9	.....	Eocene?.....	.....	

TABLE 36.—*Analyses of well waters from Early County.*

[Parts per million.]

	1 [a]	2
Silica (SiO_2)	8.0	18
Iron (Fe)	[b] .7	4.0
Calcium (Ca)	5.4	47
Magnesium (Mg)	2.0	6.0
Sodium (Na)	42	13
Potassium (K)	9.1	
Carbonate radicle (CO_3)	.0	.0
Bicarbonate radicle (HCO_3)	114	200
Sulphate radicle (SO_4)	11	8.0
Nitrate radicle (NO_3)	.....	.5
Phosphate radicle (PO_4)	Trace.	.....
Chlorine (Cl)	14	4.0
Total dissolved solids	140	208
Free carbon dioxide (CO_2)	55	.....

[a] Georgia Geol. Survey Bull. 15, p. 106, 1908. [b] $Fe_2O_3 + Al_2O_3$.

1. Town well at Blakely (No. 3, Table 35). Depth of principal water-bearing stratum, 812 feet. Edgar Everhart, analyst.
2. Well of Callahan-Powell Co. (No. 4, Table 35). Sample collected June 1, 1911. Edgar Everhart, analyst.

ECHOLS COUNTY.

GENERAL FEATURES.

Echols County is in the southern part of the State along the Florida border. Its area is 362 square miles and its population 3,309 (census of 1910). The county is sparsely settled and has no large towns or cities. Lumbering and turpentining are the principal industries.

TOPOGRAPHY.

The county is nearly level, is poorly drained, and lies 125 to 170 feet above sea level. Alapaha and Suwannee rivers have cut their valleys 40 to 60 feet below the general upland level, and each is bordered by a flat sand-covered terrace lying 10 to 15 feet above low-water level. Suwanoochee and Toms creeks and the other small streams of the county have low banks and flow through broad swampy flats.

GEOLOGY.

The Chattahoochee formation (Oligocene), which consists of 100 feet or more of limestones of greater or less purity, outcrops on Alapaha River below Statenville and probably underlies the whole county beneath younger formations. The Alum Bluff formation (Oligocene), which probably consists of 75 feet or less of phosphatic sands and greenish sandy clays, overlies the Chattahoochee formation and outcrops over the southern two-thirds of the county and in the valleys of Alapaha River and other smaller streams. In the interstream areas in the northern part of the county the Alum Bluff formation is overlain by 50 feet or less of irregularly bedded sands and clays of undetermined age.

The Alum Bluff formation weathers to gray or white sands, which cover the surface to a depth of several feet. On the terraces bordering Alapaha and Suwannee rivers a thin covering of sand of Pleistocene age has been deposited.

The limestones of the Chattahoochee formation are believed to be underlain in descending order by similar water-bearing limestones referable to the Vicksburg formation (Oligocene) and the Jackson formation (Eocene), but these formations have not been accurately differentiated.

Beneath the limestones in descending order is a series of undifferentiated sediments of Eocene and Cretaceous age, which at an unknown depth, perhaps 2,500 feet or more, rest upon a basement of ancient crystalline rocks. These sediments contain important water-bearing beds.

WATER RESOURCES.

Abundant soft water for domestic purposes is obtained chiefly from shallow dug and driven wells, in some of which the water stands within 4 or 5 feet of the surface.

The few springs yield only small quantities of water. The waters of the streams are dark to almost black from organic matter.

The population of Statenville, the county seat, is 210 (census of 1910). The town has no water-supply system and obtains water for domestic use chiefly from wells 20 to 30 feet deep and from four deep wells, the deepest of which is said to be 160 feet. One well, information concerning which has been obtained from L. C. Solomon, the driller, is owned by the Garbutt Lumber Co. It is 148 feet deep and is cased to a depth of 71 feet, at which depth rock was entered. The water, which rises to within 40 feet of the surface, is probably derived from the Chattahoochee formation. A sample collected June 7, 1911, was analyzed by Edgar Everhart:

Analysis of water from well of the Garbett Lumber Co., Statenville.

	Parts per million.
Silica (SiO_2)	34
Iron (Fe)	.2
Calcium (Ca)	25
Magnesium (Mg)	11
Sodium and potassium (Na+K)	12
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	136
Sulphate radicle (SO_4)	12
Chlorine (Cl)	12
Nitrate radicle (NO_3)	Trace.
Total dissolved solids	182

Abundant supplies of artesian water should be obtained anywhere in the county at depths less than 700 feet. Flowing wells can probably be obtained on the low terraces bordering Suwannee and Alapaha rivers.

EFFINGHAM COUNTY.

GENERAL FEATURES.

Effingham County is in the eastern part of the Coastal Plain of Georgia, its southern boundary being about 25 miles west of the Atlantic coast. Its area is 448 square miles and its population (census of 1910) is 9,971.

TOPOGRAPHY.

The county is nearly level, varying in elevation from 150 or 175 feet above sea level in the north to less than 50 feet in the south. The county is bounded on the east by Savannah River. A series of

high bluffs overlooks the river on the Georgia side, and at the foot of the bluffs are a few relatively small patches of swamp lying 8 to 10 feet above low-water level. On the South Carolina side the river is bordered by a tract of swamp several miles wide. Ogeechee River, which forms the western boundary, is bordered by a large area of low and partly swampy land. The water of Savannah River is always more or less muddy from suspended sediment; that of the Ogeechee is muddy only when the river is at flood stage. Small streams are few in number and the county is dotted with small cypress ponds and bays.

GEOLOGY.

The surface deposits in the northern two-thirds or three-fourths of the county consist of 100 feet or less of argillaceous sands and clays which weather to white or yellow sands, the latter covering the surface to a depth of a few inches to several feet. These deposits are mapped as undifferentiated Oligocene-Pleistocene. In the southern part of the county the surface is covered with a thin veneer of gray or white Pleistocene terrace sands.

The undifferentiated deposits are underlain in the eastern part of the county by 75 feet or less of sands, clays, and marls of Miocene age, which outcrop in the bluffs of Savannah River and which have been subdivided into the Marks Head marl and the Duplin marl.

Stratigraphically beneath the Miocene deposits is the Alum Bluff formation, which consists of 100 feet or more of sands, clays, and marls, probably water bearing, and which outcrops on Savannah River north of Effingham County and on Ogeechee River in the western part of the county.

The Alum Bluff formation is underlain by a series of undifferentiated limestones, sands, clays, and marls, which, in descending order, are of Oligocene, Eocene, and Cretaceous age. At an undetermined depth, probably between 2,000 and 3,500 feet, the Cretaceous deposits rest upon a basement of ancient crystalline rocks. The Oligocene, Eocene, and Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The main source of domestic water supply is wells of the dug or driven type, ranging in depth from 10 to 40 feet. These yield an abundance of soft water which, however, is not as desirable from the sanitary standpoint as the waters of deep artesian wells. Artesian wells have been reported from Eden, Meldrim, Egypt, Guyton, Pineora, and Springfield; those at Eden and Meldrim flow. Springfield is the only town in the county owning a public water-supply system.

Artesian water can be obtained anywhere in the county at depths of 200 to 800 feet or more. Flowing wells can be obtained in the southern part of the county and on the terraces bordering Ogeechee and Savannah rivers at places where the surface is 75 feet or less above sea level.

LOCAL SUPPLIES.

Springfield (population 504, census of 1910).—Springfield, the county seat, is in the central part of the county. An artesian well owned by Mr. Elliot Mingledoff supplies the town with water for general domestic purposes. The well is in a valley in the northern part of the town about 30 feet below the general level of the surrounding country and is 400 feet deep. Marl (rock) is said to have been encountered at a depth of 290 feet. The principal water-bearing bed is at the bottom of the well and the water will rise 8 feet above the surface. A hydraulic ram installed at the mouth of the well forces the water to a tank 70 feet above the surface, from which it is distributed to the consumers.

A well owned by G. M. Brinson in the southern part of the town, at a point where the surface is about 100 feet above sea level and about 30 feet higher than the surface at the mouth of the Mingledoff well, is 500 feet deep. The water stands within 24 feet of the surface.

Eden.—Wells at Eden are described by McCallie [1] as follows:

There are two wells located at this place, one 280 feet and the other 311 feet in depth. Each well has a diameter of 6 inches and furnishes a flow of several gallons of sulphureted water per minute, which rises 12 feet above the surface. Only one flow is reported in the well and this was struck at about 275 feet. The strata penetrated are said to have been clays and marls, with thin layers of hard rock.

Egypt.—A well at Egypt is described by McCallie [1] as follows:

This well was sunk by the Central of Georgia Railway. It is reported to be 750 feet deep and 4 inches in diameter. Water rises to within 45 feet of the surface. Water-bearing strata were penetrated at 300 and 750 feet from the surface. The strata passed through are said to have been clay, sand, and marls, followed by limestone.

Guyton.—A well at Guyton is described by McCallie [1] as follows:

Mr. J. T. Wells's well, which is located about a mile east of Guyton post office, was completed in 1895 at a cost of $400. The well is 3 inches in diameter and 400 feet deep; it furnishes hard, sulphureted water, rising to within 18 feet of the surface. The principal water-bearing stratum, which consists of sand, was struck at 300 feet. An incomplete record is as follows:

Well of J. T. Wells at Guyton.

	Feet.
Clay	200
Rock	200 –201½
Rocks in beds (sharks' teeth and shells)	201½–396
Quicksand	396 –400

[1] Georgia Geol. Survey Bull. 15, pp. 107–108, 1908.

Meldrim.—Wells at Meldrim are described by McCallie [1] as follows:

There are two deep wells at Meldrim, one of which was sunk by the Central of Georgia Railway. It is reported to attain a depth of 538 feet. It is 6 inches in diameter and furnishes a good flow, rising 4 feet above the surface. The daily capacity of this well is said to be about 40,000 gallons. The water is used to supply the locomotives of the Central of Georgia Railway and for general domestic purposes.

The other Meldrim well, owned by Mr. C. B. Guyer, is located about 300 yards west of the post office. It is 6 inches in diameter and 350 feet deep; it flows about 50 gallons of sulphureted water per minute. The water is said to rise 50 feet above the surface. It is used at present only for general domestic purposes, but Mr. Burnham, who furnished these data, notes that it is Mr. Guyer's intention to use the water soon for irrigation.

TABLE 37.—*Wells in Effingham County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Eden	.....	.....	S. W. McCallie [1]	.....	34
2	....do	.....	.....	....do	.....	.....
3	Egypt	Central of Georgia Ry.	.....	....do	.....	143
4	Guyton (1 mile east of).	J. T. Wells	.....	W. W. Burnham [1]	1895	.....
5	Meldrim	Central of Georgia Ry.	.....	S. W. McCallie [1]	.....	39
6	....do	C. B. Guyer	.....	....do	.....	.....
7	Springfield	Elliott Mingledoff	J. W. Showalter.	H. B. Webb	1910	.....
8	Springfield (¼ mile southeast of the post office).	Geo. M. Brinson	.....	J. H. Hodge	1908	100

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	280	6	275	.....	+12	2-3	.....	Flows	Sulphurous.
2	311	6	275	.....	+12	2-3	.....	....do	Do.
3	750	4	750	300	−45	.....	.....	.....	
4	400	3	300	.....	−18	.....	.....	.....	Hard, sulphurous.
5	538	6	.....	.....	+ 4	28	.....	Flows	
6	350	6	.....	.....	+50	50	.....	....do	Slightly sulphurous.
7	400	6	400	.....	+ 8	110	.....	....do	
8	500	8	.....	.....	−24	.....	.....	Force pump	

[1] Georgia Geol. Survey Bull. 15, pp. 107-109, 1908.

TABLE 37.—*Wells in Effingham County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	.....	Oligocene.....	.....	
2	.....	.....do.....	.....	
3	Boiler supply of locomotives.	Eocene.....	.....	
4	.....	Oligocene.....	.....	See log, p. 251.
5	Boiler supply of locomotives and domestic.	Eocene?.....	.....	
6	Domestic.....	Oligocene.....	.....	Also a flowing well at the clubhouse on Ogeechee River a short distance west of Meldrim.
7	.....do.....	Oligocene?.....	Rock.....	
8	Domestic; manufacturing; general.	Eocene?.....	.....	

EMANUEL COUNTY.

GENERAL FEATURES.

Emanuel County is in the northeast-central part of the Coastal Plain of Georgia in the area popularly known as the wire-grass region. Its area is 935 square miles and its population 25,140 (census of 1910). Cotton, lumber, and naval stores are the principal products. Manufacturing establishments are few in number and small. Water is not extensively used industrially. Artesian water is used in the manufacture of ice at Swainsboro.

TOPOGRAPHY.

The county is rolling to slightly hilly. Creeks and branches are numerous and occupy shallow valleys. Accurate determinations of altitude have not been made, but the upland is thought to be from about 250 to 400 feet above sea level. The highest land is the upland in the northern part of the county; the lowest is in the valleys of Ogeechee, Ohoopee, and Canoochee rivers, which are bordered by terrace plains 200 feet or less above sea level.

GEOLOGY.

The surface terrane throughout practically all the county consists of probably less than 100 feet of ferruginous coarse sands with subordinate clay lenses, locally indurated to hard sandstones or claystones. These materials weather to loose gray sands which cover the surface to depths of 3 to 25 feet. The surface sands absorb rainfall rapidly and their contained waters are tapped at a few places by shallow wells. Many small springs issue from the contact between the gray sands and the underlying unweathered materials.

The surficial deposits are underlain by the Alum Bluff formation, which consists of 100 feet or more of bluish to drab sandy clays and

TABLE 38.—*Wells in Emanuel County*—Continued.

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	350	4	.....	.....	+30	40	.....	Flows.....	Soft.
2	300?	.....	.....	.....	.....	.....	10	.....	
3	110	.....	.....	.....	+ 2	1½	.....	Flows.....	
4	400	6	100	100	−80	.....	5	Pumped; gasoline engine.	Do.
5	600	3	.....	.....	−50	.....	.....	Steam engine and air-lift pumps.	
6	679	6	.....	.....	−70	.....	.....	.....	Hard.
7	300	.....	.....	.....	.....	.....	.....	Pumped.....	
8	400	6	370	.....	−90	.....	.....	Deep-well pump..	
9	400	2	.....	.....	−90	.....	.....	.....	
10	889	.....	.....	.....	.....	.....	.....	Pumped.....	
11	400±	4	300–400±	.....	−85	.....	60	Air-lift pump.....	Sulphurous.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic.....	Vicksburg formation?	.....	
2	Municipal supply.	.....do.....	.....	
3	.....	Alum Bluff formation?	.....	
4	Domestic, manufacturing.	.....do.....	.....	Cost of well, $500; cost of machinery, $150.
5	Domestic, manufacturing, boiler-supply.	Eocene.....	.....	
6	.....	.....do.....	.....	
7	Domestic.....	Claiborne group...	.....	
8	Domestic, manufacture of ice.	Eocene.....	Sand.....	Cost of well, $800; cost of machinery, $200. Operated by the Swainsboro Gin & Warehouse Co.
9	.....	.....do.....	.....	
10	Public supply.....	Cretaceous?.....	.....	
11	Manufacturing....	Eocene.....	.....	Cost of well, $1,000; cost of machinery, $500; 4-inch casing to 300 feet. The well was repaired (not drilled) by the Hughes Specialty Well Drilling Co., Charleston, S. C.

GLASCOCK COUNTY.

GENERAL FEATURES.

Glascock County is in the northeastern part of the Coastal Plain of Georgia. Its area is 170 square miles and its population is 4,669 (census of 1910). Agriculture is the chief industry.

TOPOGRAPHY.

The county is included in the physiographic division of the Coastal Plain known as the fall-line hills. The surface, which was at one time an upland plain, has become hilly as the result of the erosive action of Ogeechee River, Rocky Comfort Creek, and the numerous tributaries of the two streams, by which the county is drained. The topographic relief of the county probably does not exceed 200 feet.

GEOLOGY.

Crystalline basement rocks, which are exposed in the beds of the streams at a few places, underlie the sediments of the Coastal Plain throughout the county. Lower Cretaceous deposits, consisting of coarse, irregularly bedded, arkosic sands with interbedded lenses of light-colored massive clay, rest upon the basement rocks and probably reach a maximum thickness of 200 or 300 feet in the extreme south. One hundred feet or less of sands and clays belonging to the Claiborne group of the Eocene rest upon the Lower Cretaceous deposits over a considerable part of the county, especially in the southeast and east. The Claiborne strata at one time covered the entire area but have been partly removed by erosion.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Wells 15 to 100 feet deep, commonly of the dug type, and springs are the chief sources of water for domestic use. They draw from porous beds of sand in the Cretaceous or Eocene deposits. Both wells and springs yield waters well adapted for domestic and industrial purposes. The waters of the numerous streams are excellent for stock and for making steam.

Lower Cretaceous deposits underlie practically all the county, but their maximum thickness is probably not more than 200 or 300 feet. Beds of porous sand are numerous and contain considerable quantities of excellent water. Over parts of the area it is necessary to drill through overlying Eocene strata before reaching the underlying Lower Cretaceous beds. The Eocene deposits, which in places probably reach a thickness of 100 feet, also carry moderate amounts of water in interbedded layers of sand.

LOCAL SUPPLIES.

Gibson (population 367, census of 1910).—Gibson, the county seat, owns a public artesian well which taps a water-bearing bed in the Lower Cretaceous. Mayor T. A. Walden has furnished the following information:

The well was completed in 1909, and is in the public square in front of the courthouse. The depth is 151 feet and the diameter 4 inches. The only water-bearing bed recognized was entered at 150 feet, and yielded water rising to within 20 feet of the surface. Casing extends to the bottom of the well. The water is lifted by a force pump having a capacity of 10 gallons a minute, which is operated by water power furnished by a near-by stream. A sample of the water, collected May 31, 1911, was analyzed by Edgar Everhart as follows:

Analysis of water from town well at Gibson.

	Parts per million.
Silica (SiO_2)	41
Iron (Fe)	4.0
Calcium (Ca)	9.0
Magnesium (Mg)	1.0
Sodium and potassium (Na+K)	15
Bicarbonate radicle (HCO_3)	74
Sulphate radicle (SO_4)	6.0
Nitrate radicle (NO_3)	.1
Chlorine (Cl)	4.0
Total dissolved solids	121

GLYNN COUNTY.

GENERAL FEATURES.

Glynn County is one of the seacoast counties in the southeastern part of the Coastal Plain of Georgia. Its area is 439 square miles and its population 15,720 (census of 1910). Lumber, naval stores, and railroad crossties are the principal products. The rural districts are rather sparsely settled, the greater part of the population being centered at Brunswick, the county seat. Agriculture is not carried on as extensively as in the inland counties.

TOPOGRAPHY.

The greater part of the county is a low, flat, terrace plain covered by extensive swamps and lying less than 25 feet above sea level. A narrow northeast-southwest area in the western part of the county is 50 or 60 feet above sea level. The streams enter the ocean through "drowned" valleys that have been submerged by the sea in geologically recent times. This submergence also caused the formation of low islands, a network of tidal waterways, and large areas of salt marsh. The effects of the ocean tides are felt in Altamaha River, which forms the northern boundary of the county, to a point about 15 miles above Darien, the river being bordered by tidal swamps that extend several miles above the salt marshes. Little Satilla and Turtle rivers are short tidewater streams. Tributary creeks and branches are few in number and have only slightly dissected the surface, which is topographically youthful.

GEOLOGY.

The surface formations of the county are of Pleistocene age. On the islands and on much of the mainland, especially near the coast, they are fine white or yellowish quartz sands, and in the extensive swamps and so-called flatwoods in the western part of the county they are mainly clays. The Pleistocene deposits do not exceed 50

feet in thickness and over the greater part of the area are probably much thinner. They are the source of the water obtained in most of the shallow wells. In the marshes mud or silt of Recent age overlies the Pleistocene deposits and the beaches and islands are covered with Recent sands.

The thin covering of Pleistocene deposits is underlain by an undetermined thickness of Miocene sands, in part phosphatic, and clays with thin interbedded layers of indurated marl and limestone.

The Miocene is underlain by a series of sands, clays, marls, and limestones, in descending order of Oligocene, Eocene, and Cretaceous age, which have never been completely penetrated by well borings and whose aggregate thickness is therefore unknown. At some unknown depth, probably 3,000 feet or more, the Cretaceous deposits are believed to rest upon a basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Wells, mostly of the driven type, ranging in depth from 6 to 30 feet, are common. Throughout the greater part of the county the water table stands within a few feet of the surface, so that small suction pumps suffice to lift the water from the wells. The waters obtained are soft, but owing to the low, swampy condition of most of the county they are considered less wholesome than artesian waters. On the islands, soft waters of fair quality are obtained at depths of 6 to 25 feet.

There are a few small seepage springs of no importance. The waters of ponds, streams, and swamps are used to some extent for stock and for steam production.

Many flowing artesian wells from 300 to 1,000 feet deep, on both the mainland and the islands, yield large quantities of water. The artesian waters are moderately hard and emit rather strong odors of hydrogen sulphide, but are potable and are more wholesome than waters from other sources. It is practicable to utilize the waters for irrigation, but it should be remembered that an extremely heavy drain on the artesian reservoirs at local points may lower the static head sufficiently to cause the wells to cease flowing.

Brunswick is the only large town in the county and the only town having a public water-supply system. Artesian wells have been drilled at all the post offices and villages and are the chief source of water for domestic purposes.

Flowing wells of large yield can be obtained throughout the county at depths of 300 to 1,000 feet or more.

LOCAL SUPPLIES.

Brunswick (population 10,182, census of 1910).—The present municipal water supply of Brunswick is obtained from a flowing well (No. 5, Table 39) 1,003.5 feet deep owned by the Mutual Light & Water Co., at 1525 Grant Street. The public water supply at Brunswick was formerly obtained from three artesian wells (No. 4, Table 39) at the waterworks pumping station. Originally the wells supplied the needs of the city, but the yield decreased so greatly that it became necessary to install pumps. The cause of the decrease is not known, but it can not be attributed to a general overdraft on the underground supply, for other wells in the city and county continue to yield large flows, and it is probably due to a local overdraft in the immediate vicinity of the pumping station.

In addition to the city wells there are many flowing artesian wells in and near the city, which range in depth from 300 to 1,000 feet and yield large quantities of wholesome water.

The following log of a well (No. 10, Table 39) recently drilled by H. J. Linniman for the Southern Naval Stores Construction Co. has been furnished by Mr. Robert June:

Log of well No. 3 of the Southern Naval Stores Construction Co., Brunswick (No. 10, Table 39).

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Sand	53	0	53	0
Hard and soft limestone	37	0	90	0
Sand, water bearing	7	0	97	0
Hard limestone	1	2	98	2
Bed of shells	11	10	110	0
Hard limestone		9	110	9
Gravel, composed of small black and white pebbles	6	3	117	0
Marl	73	0	190	0
Hard marl	6	0	196	0
Marl, with thin, indurated layers	84	0	280	0
Mud and fine sand; first flow at 300 feet	60	0	340	0
Marl, with thin indurated layers and soft sandstone	100	0	440	0
Limestone	30	0	470	0
Porous limestone; second flow	20	0	490	0
Hard limestone	10	0	500	0
Sand	20	0	520	0
Massive white limestone	40	0	560	0
Porous limestone and layers of sand; contain shells; third flow at 650 feet	440	0	1,000	0

A sample from a depth of 650 feet consists of a porous phosphatic sand cemented by silica and calcium carbonate. It contains fragments of oyster shells and other fossils, none of which are well enough preserved for specific identification. The flow at 300 feet exerts a pressure of one-half pound per square inch at the surface; the second flow, between 470 and 490 feet, exerts a pressure of 8 pounds; and the third flow, at 650 feet, exerts an estimated pressure of 22 pounds. When this well was completed the yield of well No. 2 (No. 9, Table 39), distant about 200 feet, the depth of which is 650+ feet,

decreased from 700 to 500 gallons per minute. McCallie[1] gives the following additional information concerning wells at Brunswick:

Col. C. P. Goodyear's well, for instance, located in the southern part of the city, is reported to reach a depth of 822 feet. This well penetrated water-bearing strata at 302, 425, and 525 feet, the latter stratum furnishing a flow of 250 gallons per minute. The water from these different horizons rises about 12, 28, and 57 feet, respectively, above the surface.

Mr. Fred Baumgartner, the well contractor, who put down many of the Brunswick wells, has furnished the Survey the following record of the high-school well [No. 6, Table 39]:

[*Log of high-school well at Brunswick (No. 6, Table 39).*]

	Feet.
Yellow sand	0– 55
Thin layers of sandstone interlaminated with clay	55–112
Blue clay or marl	112–212
Soft porous limestone with shells	312–332
Coarse sand and pebbles	332–357
Hard rock	357–359
Blue marl or clay	359–459
Thin layers of limestone with clay and sand	459–479
Very fine white sand at	479

An analysis of water from the high-school well is given in Table 40 (analysis 2).

Thalman.—W. A. Morgan, of Eastman, owns a flowing well (No. 18, Table 39) at Thalman, the water of which is notable for its large content of sulphate. The well is about 50 yards south of the depot, is reported to be 400 feet deep, and flows several feet above the surface. The water emits a very strong odor of hydrogen sulphide. (See Table 40, analysis 8.) It is used principally for drinking.

Jointer Island.—According to George Kennedy, one of the original owners, a flowing well (No. 15, Table 39) on Jointer Island, 4 miles south of Brunswick, penetrated sands, gravels, and layers of shells, with interstratified layers of hard flintlike rock at intervals of about 15 feet. Water was found beneath a layer of hard rock at 260 feet, in a cavity or in soft sand which allowed the drill to drop about 15 feet. (See analysis 6, Table 40.)

St. Simons Island.—Wells on St. Simons Island are described by McCallie[2] as follows:

There are four artesian wells reported on St. Simons Island, varying in depth from 438 to 465 feet. The only one of these wells from which anything like a detailed account has been preserved is the Hilton & Dodge Lumber Co.'s well at St. Simons Mills. This well, which was sunk in 1886, is 6 inches in diameter and 438 feet deep. It furnishes 250 gallons of sulphureted water per minute. The water rises 40 feet above the surface. It is largely used for steam purposes. The first flow in this well was struck at 350 feet. It yielded 8 gallons per minute. The second flow began at 435 feet and gradually increased to the bottom of the well.

[1] Georgia Geol. Survey Bull. 15, pp. 111, 112, 1908. [2] Idem, pp. 115, 116.

The following notes on the different strata penetrated in the well on St. Simons Island (No. 16, Table 39) were made by Mr. McCallie[1] from a series of borings furnished by the Hilton & Dodge Lumber Co.:

Log of Hilton & Dodge Lumber Co.'s well on St. Simon Island (No. 16, Table 39).

	Feet.
Very fine gray sand to	10
Dark-colored marsh mud containing fragments of shells to	20
Rather coarse gray sand with fragments of oyster and other shells to	40
Quite similar to overlying sand, somewhat coarser, with only a few shells to	50
Coarse gray sand and water-worn pebbles of quartz and feldspar to. The pebbles are often an inch or more in diameter.	60
Very coarse sand and water-worn pebbles of quartz and feldspar to. The pebbles are often an inch or more in diameter.	70
Moderately coarse sand and pebbles and comminuted shells to	80
Fine dark-gray sand and pebbles to	90
Fine brown sand and a few angular quartz pebbles with clay to	100
Fine dark-gray sand, similar to that found at 90 feet	110
A conglomerate of quartz pebbles and coarse sand with clay matrix to. There occur in the conglomerate a few dark or brown-colored, small, rounded particles, consisting largely of calcium phosphate.	115
Coarse gray sand and fragments of shells to. The sand granules are well rounded and consist of feldspar of dark color.	120
The same as above except that the fragments of shells are more abundant to	125
Fine gray sand with some mica to	133
Fine gray sand and quartz pebbles to	143
Similar to the above except darker and with less clay to	153
Fine gray sand with mica to	170
Fine gray sand to	180
Fine light-gray sand with much mica to	190
Fine dark-gray, clayey sand with mica, diatoms, and spicules of sponges to	200
The same as above but darker to	230
Fine sand with numerous diatoms and spicules of sponges to	250
Diatomaceous earth, containing an innumerable number of microscopic rhombohedral crystals of calcite to	310
Fine light-gray, micaceous sand with mica and small teeth resembling those of the gar pike to	320
Rather coarse gray sand containing sharks' teeth, dental plates of rays (?), fragments of bones, and small pieces of clay containing diatom shells and sponge spicules to	324
Gray sandstone or quartzite containing casts of shells and glauconite to	327
Moderately coarse gray sand to	330
Coarse water-worn sand with small sharks' teeth to	350
The same as above except that it contains fragments of shells to	360

[1] Georgia Geol. Survey Bull. 15, pp. 115–116, 1908.

	Feet.
Dark-gray marl made up largely of microscopic crystals of calcite to..	400
Very compact, fine, dark-gray clay, slightly tinged with green, to..	410
Fine dark-gray clay, frequently indurated, glauconite more or less abundant, to	420
Coarse, dark-colored, glauconitic sand containing small teeth of sharks to	430
Coarse dark sand with rounded pebbles of quartz and feldspar to...	435
Fine white sand to	438

Bladen.—A well at Bladen (No. 1, Table 39) is described by McCallie[1] as follows:

The Bladen deep well, owned by Mr. J. A. Ward, has a depth of 480 feet. It is 3 inches in diameter, and flows about 100 gallons per minute. The water, which is used for domestic and steam purposes, rises 30 feet above the surface. It is hard and sulphureted. Water-bearing strata are reported at 160, 260, and 475 feet, respectively. Nothing is known of the strata penetrated in the well, except that they consist of clay and sand, with a few beds of rock and oyster shells.

Everett City.—A well (No. 12, Table 39) at Everett City is described by McCallie[1] as follows:

Mr. R. H. Everett's well, at Everett City, was put down in 1894. It is 460 feet deep and 2 inches in diameter, and it furnishes a flow 38 feet above the surface. The water is hard and sulphureted and is used for domestic and steam purposes. No record of the well was secured.

Crispin.—McCallie describes a well near Crispin (No. 7, Table 39) as follows:[2]

A flowing well, owned by Mr. Harry Gignilliat, and located 6 miles northwest of Brunswick, on the road leading to Crispin, has a depth of 377 feet. It is 4 inches in diameter and it furnishes 50 gallons of sulphureted water per minute. Water-bearing strata are reported at 200 and 270 feet, respectively. Water from the first stratum is said to rise to within 8 feet of the surface, and from the last 14½ feet above the surface.

Mr. L. L. Deering, the well contractor, gives the following record of the Gignilliat well:

[*Log of well of Harry Gignilliat, near Crispin (No. 7, Table 39).*]

	Feet.
Sand	0– 4
Clay	4– 12
Sand	12– 14
Clay	14– 26
Sand	26– 36
Clay	36– 46
Sand and shells	46– 66
Rock	66– 68
Clay	68– 88
Sand rock	88–100
Clay	100–130
Rock	130–133
Clay	133–163
Sand	163–168

[1] Georgia Geol. Survey Bull. 15, p. 117, 1908.

[2] Idem, p. 118.

	Feet.
Clay	168–188
Rock	188–191
Sand and shells, water bearing	191–220
Clay	220–230
Sand	230–272
Clay	272–280
Sand	280–288
Clay	288–304
Rock	304–310
Clay	310–325
Rock	325–327
Clay	327–357
Rock	357–362
Clay	362–370
Rock, water bearing	370–377

Evelyn.—A well at Evelyn (No. 11, Table 39) is described by McCallie[1] as follows:

Mr. T. J. Dent's well at Evelyn, in the northern part of Glynn County, has a depth of 420 feet. It is 2 inches in diameter, and the water rises 14 feet above the surface. The first flow was struck at 370 feet from the surface; but the well was continued to 420 feet without increase of flow. The water is sulphureted, and is used for farm and general domestic purposes.

Jekyl Island.—A well on Jekyl Island (No. 14, Table 39) is described by McCallie[2] as follows:

The well of the Jekyl Island Club, which furnishes 250 gallons per minute, is 6 inches in diameter and 480 feet deep. The flow of the well is said to have perceptibly decreased since its completion. Whether this decrease is due to an accumulation of sand in the casing or to an overdraft on the water-bearing stratum is not known. [See analysis 5, Table 40.]

TABLE 39.—*Wells in Glynn County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Bladen	J. A. Ward		S. W. McCallie[3]	1894	15?
2	Brunswick	C. P. Goodyear	Fred Baumgartner.	do.[3]		14?
3	Brunswick, 2 miles north of.	H. W. Loyd		do.[3]		
4	Brunswick (three city wells).	City		do.[3]		14?
5	Brunswick	Mutual Light & Water Co.	Southern Contracting Co.	H. F. Dunwoody, mgr. Mutual Light & Water Co.	1912	20
6	Brunswick public high school.	City		S. W. McCallie[3]		14?
7	Crispin, near, 6 miles northwest of Brunswick.	Harry Gignilliat	L. L. Deering	do.[3]		

[1] Georgia Geol. Survey Bull. 15, p. 119, 1908. [2] Idem, p. 114. [3] Idem, pp. 111–119.

TABLE 39.—*Wells in Glynn County*—Continued.

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
8	Brunswick, 1½ miles northwest of.	Southern Naval Stores Construction Co. (well No. 1).	.....	Robert June.....	.....	12
9	.....do.....	Southern Naval Stores Construction Co. (well No. 2).	.....	.....do.....	.....	12
10	.....do.....	Southern Naval Stores Construction Co. (well No. 3).	H. J. Linniman.	.....do.....	1911	12
11	Evelyn.....	T. J. Dent.....	.....	S. W. McCallie [a]...	.....	.....
12	Everett City.....	R. H. Everett.....	.....	.....do.[a].....	1894	16
13	Everett City (Ocean View Hotel).	W. H. Crofton.....	.....	Owner.....	1905	16
14	Jekyl Island.....	Jekyl Island Club....	.....	S. W. McCallie [a]..	.....	.....
15	Jointer Island, 4 miles south of Brunswick.	Leon E. Robarts, Brunswick.	George and Oliver Kennedy, Brunswick.	Owner.....	1900	6
16	St. Simons Island....	Hilton & Dodge Lumber Co., St. Simons Mills.	.....	S. W. McCallie [a]...	1886	.....
17	St. Simons Island (Ocean View Hotel).	W. Arnold.....	Fred Baumgartner, Brunswick.	A. T. Arnold.....	.....	.....
18	Thalman, at depot....	W. A. Morgan, Eastman.	.....	Owner.....	.....	±20

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Height of water above surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	480	3	475	160, 260	30	100	.....	Flows.....	Hard, sulphurous.
2	822	.....	525	302, 425	57	250	.....	.....do.....	Do.
3	485	4	.....	.....	27	.....	.....	.....do.....	Hard, sulphurous; analysis 3, Table 40.
4	300–500	.....	.....	.....	.....	.....	.....	Pump.....	Hard, sulphurous.
5	1,003.5	10	540–1,002.5	250–300	.....	2,794	.....	Flows.....	Analysis 1, Table 40.
6	479	.....	.....	.....	.....	.....	.....	.....	Analysis 2, Table 40.
7	377	4	270	200	14½	50	.....	Flows.....	Hard, sulphurous.
8	650	4½	650?	.....	.....	+600	.....	.....do.....	
9	650+	6	650?	.....	.....	+500	.....	.....do.....	
10	1,000	10	650	320, 490	.....	+3,500	.....	.....do.....	
11	420	2	370, 420	.....	14	.....	.....	.....do.....	Hard, sulphurous.
12	460	2	.....	.....	38	.....	.....	.....do.....	Do.
13	350±	2	.....	.....	30	.....	.....	.....do.....	Analysis 4, Table 40.
14	480	6	.....	.....	.....	250	.....	.....do.....	Hard, sulphurous; analysis 5, Table 40.
15	275	3	260–275	.....	30	.....	.....	.....do.....	Analysis 6, Table 40.
16	438	6	435–438	350	40	250	.....	.....do.....	Hard, sulphurous.
17	500	.....	.....	.....	.....	.....	.....	.....	Analysis 7, Table 40.
18	400	.....	400	.....	.....	40	.....	Flows.....	Sulphurous; analysis 8, Table 40.

[a] Georgia Geol. Survey Bull. 15, pp. 111–119, 1908.

TABLE 39.—*Wells in Glynn County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic, boiler supply.	Tertiary		2 wells on Smith plantation.
2		do		
3	Irrigation			
4	Former municipal supply.	Tertiary		Flowed when first drilled.
5	Municipal supply.	do	Limestone, sand, etc.	Cost of well $5,476; 12-inch casing to 440 feet; the first good flow was obtained at 560 feet; flow increased to 800 feet, also considerably between 900 and 1,002.5 feet. Well finished in hard, white limestone, which was penetrated 1 foot.
6		do		See log, p. 261.
7		do		See log, pp. 263–264.
8	Distillation of wood.	do	Porous limestone	6-inch casing to 200 feet; 4½-inch casing to bottom.
9	do	do	do	Cost of well $3,000; 8-inch casing to 200 feet; 6-inch casing to bottom; yield decreased from 700 to 500 gallons a minute when well No. 3 was drilled. Discharges 7 feet above surface.
10	do	do	do	14-inch casing to 195 feet; 10-inch casing to bottom. Discharges 4 feet above surface. See log, p. 260.
11	Domestic; farm	do		
12		do		
13	Domestic	do		Cost of well, $300.
14		do		
15	Domestic	do	Sand	3-inch casing to about 75 feet.
16	Boiler supply, etc.	do		3 other artesian wells on the island range in depth from 438 to 465 feet. See log, pp. 263–264.
17	Domestic and irrigation.	do		
18	Drinking	do		

TABLE 40.—*Analyses of underground waters from Glynn County.*

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	Dec. 18, 1912	Well of Mutual Light & Water Co.	Brunswick	Tertiary	540–1,002.5	Edgar Everhart.
2		High school well.	do	do	302	Do.[a]
3		Well of H. W. Loyd.	Brunswick, 2 miles north of.	do	485	Do.
4	June 2, 1911	Well of W. H. Crofton.	Everett City	do	350	Do.
5		Well of the Jekyl Island Club.	Jekyl Island	do	480	H. C. White.[a]
6	Feb. 17, 1913	Well of Leon E. Robarts.	Jointer Island, 4 miles south of Brunswick.	do	260–275	Edgar Everhart.
7	June 10, 1911	Well of W. Arnold.	St. Simons Island at Ocean View Hotel.	do	500	Do.
8	Dec., 1909	Well of W. A. Morgan.	Thalman (at depot).	do	400	Do.

[a] Georgia Geol. Survey Bull. 15, pp. 112–114, 1908.

TABLE 40.—*Analyses of underground waters from Glynn County*—Continued.

[Parts per million.]

No.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	39	2.0	.....	42	25	15		0.0	163	91	Tr.	17	.....	304	Well 5, Table 39.
2	24	5.4[a]	.....	31	18	23	7.6	.0	126	64	Tr.	17	.....	271	Total depth, 479 feet. Free carbon dioxide (CO_2)=7. Well 6, Table 39.
3	15	27[a]	.....	33	7.5	50	2.4	.....	120	84	0.7	27	.....	308	Free carbon dioxide (CO_2)=.0. Well 3, Table 39.
4	14	.1	.....	37	4.0	67		Tr.	172	103	.3	17	.....	340	Well 13, Table 39.
5	1.2	.....	.....	62	2.0	31	.8	83	.....	69	.....	16	22	287	Well 14, Table 39.
6	47	8.0	5.0	43	23	34		.0	212	128	.0	17	.....	389	Well 15, Table 39.
7	28	Tr.	.....	11	1.0	57		.0	164	16	.0	18	.....	202	Well 17, Table 39.
8	12	1.5	.....	24	15	52	.5	.....	128	101	Tr.	28	.....	291	Well 18, Table 39.

[a] $Fe_2O_3+Al_2O_3$.

GRADY COUNTY.

GENERAL FEATURES.

Grady County is in the southwestern part of the Coastal Plain of Georgia, along the Florida border. Its area is 444 square miles and its population 18,457 (census of 1910). Cotton, corn, sugar cane, lumber, and naval stores are the chief products. The manufacture and shipment of "Georgia" cane sirup is an important local industry.

TOPOGRAPHY.

The northern part of the county is nearly level to gently undulating, and for the most part has the characteristic topography, soil, and vegetation of the Altamaha upland or wire-grass region. South of Cairo and Whigham the relief becomes stronger, and in places the surface is hilly though not rugged. Throughout the county lime sinks and lime-sink ponds characterize the topography. Most of the county is drained by Ochlockonee River and its tributaries, but a small area in the northwest drains into the "Big Slough"—a narrow area of lowland about 20 miles long lying principally in Mitchell and Decatur counties, but touching the northwest corner of Grady County. The valleys of the small creeks and branches are shallow and the waters of the streams spread out through the swamps which border their courses. Ochlockonee River is a sluggish, black-water stream which flows canal-like through a terrace plain half a mile to a mile wide lying 10 to 15 feet above the river level.

The altitude at Cairo is 237 feet and at Whigham 265 feet above sea level. The surface north of the Atlantic Coast Line Railroad is somewhat higher and south of it is somewhat lower than at Whigham.

GEOLOGY.

The Vicksburg formation, which consists of 200 feet or more of porous and cavernous water-bearing limestones, underlies the entire county, but appears at the surface only in one small area in the extreme northwest. This limestone is overlain by the Chattahoochee formation, which consists of approximately 100 feet of cavernous water-bearing limestones and which outcrops in a narrow area in the northwest and on Ochlockonee River in the south, and is exposed in both sections in the walls of numerous lime sinks.

The Chattahoochee formation is overlain by 100 feet or less of sandy clays and sands belonging to the Alum Bluff formation, which outcrops in a narrow area in the northwest, in a somewhat larger area in the south, and in the valleys of Ochlockonee River and its tributaries from the Florida line to the northeastern corner of the State. Throughout the greater part of the county the Alum Bluff formation is overlain by 50 feet or less of irregularly bedded argillaceous sands and sandy clays of undetermined age.

The Vicksburg formation is underlain by limestones belonging to the Jackson formation, and the latter is underlain in descending order by undifferentiated Eocene and Cretaceous strata, probably having an aggregate thickness of 2,000 feet or more, which do not appear at the surface within the county. The Cretaceous deposits rest upon a deeply buried basement of crystalline rocks. The Eocene and Cretaceous deposits contain water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

In the rural districts water supplies for domestic use are obtained chiefly from dug wells ranging in depth from 20 to 50 feet. Small springs scattered through the county are used locally for general domestic purposes. One artesian well each has been reported from Cairo, Whigham, Calvary, and Beachton.

Artesian water can be reached throughout the county at depths of 100 to 1,000 feet or more, but it is doubtful if any flows can be obtained.

LOCAL SUPPLIES.

Cairo (population 1,505, census of 1910).—A public water-supply system is owned by the town of Cairo. Water is derived from an artesian well (No. 2, Table 41) 10 feet above the level of the track at the Atlantic Coast Line Railroad station. The depth of the well is 750 feet, and the water is reported to come from a rock stratum, probably of Eocene age, at the bottom. The static head is 200 feet below the surface, and the yield by pumping is 125 gallons per minute. The sulphate content is much greater than has been noted

in most other Coastal Plain waters of Georgia. A sample taken on May 13, 1911, was analyzed by Edgar Everhart, with the following results:

Analysis of water from town well at Cairo (No. 2, Table 41).

	Parts per million.
Silica (SiO_2)	24
Iron (Fe)	.4
Calcium (Ca)	54
Magnesium (Mg)	12
Sodium and potassium (Na+K)	28
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	173
Sulphate radicle (SO_4)	112
Nitrate radicle (NO_3)	.2
Chlorine (Cl)	19
Total dissolved solids	342

Whigham (population 627, census of 1910).—The principal source of water supply at Whigham is an artesian well (No. 4, Table 41) 432 feet deep owned by the town. Two water-bearing beds are reported to have been penetrated, one at 200 feet and the other, the principal one, at 430 feet. The well is cased to 250 feet and the water rises to within 30 feet of the surface.

Calvary (population 225, census of 1910).—A well at Calvary (No. 3, Table 41), owned by the village, is 372 feet deep, and the water, which stands within 63 feet of the surface, is reported to be of satisfactory quality for domestic use. Rock was encountered in the well at a depth of 100 feet.

Beachton.—McCallie[1] gives the following data relating to a well (No. 1, Table 41) near Beachton, a small village in the southwestern part of the county:

This well, owned by Mr. S. M. Beach, is located in the southern part of the county near the Georgia-Florida line. It is 6 inches in diameter and 110 feet deep; it furnishes a copious supply of water, rising to within 40 feet of the surface Solid rock was struck at 85 feet. The only water-bearing stratum reported occurs at the bottom of the well.

TABLE 41.—*Wells in Grady County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Beachton	S. M. Beach		S. W. McCallie[1]		
2	Cairo	Public	William Miller	K. P. Wright	1906	247
3	Calvary	Town		Postmaster		
4	Whigham	....do				265

[1] Georgia Geol. Survey Bull. 15, pp. 180, 181, 1908.

TABLE 41.—*Wells in Grady County*—Continued.

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	110	6	110	.....	40	.....	.....	.....	
2	750	3	750	.....	200	.....	125	Air-lift pump.....	See analysis, p. 269.
3	372	.....	.....	.....	63	.....	.....	.....	
4	432	6	430	200	30	.....	.....	.....	Sulphurous.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	.....	Chattahoochee formation?	.....	
2	Domestic, manufacturing.	Eocene.....	Rock.....	3-inch casing to 350 feet. Cost of well, $1,200; cost of machinery, $1,500.
3	Domestic.....	Vicksburg formation.	.....	
4	.....do.....	.....do.....	Rock.....	6-inch casing to 250 feet. Cost of well, $1,200; cost of machinery, $275.

HANCOCK COUNTY.

GENERAL FEATURES.

Hancock County is in the northeast-central part of Georgia on the border between the Piedmont Plateau and the Atlantic Coastal Plain. Its area is 530 square miles and its population (census of 1910) is 19,189. Agriculture is the chief industry.

TOPOGRAPHY.

Less than half the county is within the Coastal Plain and nearly all of this portion lies south of the Georgia Railroad, the remainder falling within the Piedmont Plateau. The Coastal Plain area forms a part of the physiographic division known as the fall-line hills. The surface is hilly, having been considerably dissected by headwater streams of Town and Buffalo creeks, tributaries of Oconee River, and by headwater streams of Ogeechee River, which drain it. The maximum surface relief is probably between 250 and 350 feet.

GEOLOGY.

Crystalline rocks of the Piedmont Plateau region outcrop at the surface over the northern half of the county. In the southern half the southward-sloping surface of the crystalline rocks is buried beneath deposits of the Coastal Plain except where they are exposed by erosion in the beds of the larger streams. The deposits of the Coastal Plain are for the most part of Lower Cretaceous age and consist of coarse irregularly bedded sands with interbedded lenses of massive

light-colored clays, reaching a probable maximum thickness of 150 or 200 feet in the extreme south. In a limited area in the southeast the Lower Cretaceous deposits are unconformably overlain by a relatively thin overlap of sands and clays which belong to the Claiborne group of the Eocene. (See Pl. III, p. 52.)

The texture, composition, and structure of the Lower Cretaceous strata are favorable to the absorption and circulation of waters in moderate quantities, the amount available at any given place being determined by the thickness of the deposits and the local drainage conditions.

WATER RESOURCES.

In the Cretaceous area in the southern part of the county water for domestic use is obtained from dug wells 10 to 100 feet deep, which tap the water-bearing sands of the Lower Cretaceous deposits, and from small springs. The wells, as a rule, are fitted with bucket and rope for lifting the water to the surface.

The waters from both wells and springs are soft and of excellent quality except at places where insanitary surface conditions are close enough to cause contamination.

The Lower Cretaceous deposits probably do not attain sufficient thickness within the county to afford water which can be classed as artesian under the topographic conditions. Along the extreme southeastern border the deposits are perhaps 150 to 200 feet thick and doubtless contain water-bearing beds of some importance; but they probably develop little artesian pressure within the county. Northward, toward the Piedmont border, the quantity of water carried by the beds is less, and only moderate supplies for domestic purposes can be obtained. Over the greater part of the area wells sunk more than 100 feet would enter the underlying basement crystalline rocks.

HOUSTON COUNTY.

GENERAL FEATURES.

Houston County is located in the north-central part of the Coastal Plain of Georgia. Its area is 585 square miles and its population is 23,609 (census of 1910). Agriculture and horticulture are the chief industries.

TOPOGRAPHY.

From the latitude of Grovania northward the county is included within the physiographic division of the fall-line hills and is part of a dissected upland plain, much of which has been rendered hilly by stream erosion. However, a tract surrounding Fort Valley in the northwest has been but slightly dissected and presents a nearly level plain. The remainder of the county south of the latitude of Grovania falls within the physiographic division of the Dougherty plain.

In the extreme south this plain is characterized by nearly level tracts 75 to 100 feet lower than the plain at Fort Valley. The Dougherty plain is not sharply separated from the fall-line hills, the two types of topography merging gradually.

In the valley of Ocmulgee River two relatively narrow terrace plains of Pleistocene age have been developed, one lying 10 to 20 feet and the other 60 to 75 feet above low-water level.

The county is drained chiefly by Ocmulgee River through its tributaries, Echaconnee, Big Indian, Tuscawhachee, and several smaller creeks. A relatively small area in the southwest is drained into Flint River through Hogcrawl Creek. The surface relief of the county probably does not exceed 300 feet.

GEOLOGY.

Deposits of Cretaceous age underlie the whole county, but are concealed from view by overlapping Eocene strata except where the Eocene beds have been removed by erosion, in the valleys of Ocmulgee River, Echaconnee Creek, Indian Creek, and their tributaries in the northern half of the county. In a belt several miles wide, along the northern border of the area, the partly buried Cretaceous beds belong to the Cusseta sand member of the Ripley formation, and to the south of this, in a belt several miles wide extending east and west across the county, they belong to the Providence sand member of the Ripley formation. The Providence sand rests conformably upon the Cusseta sand, but the two divisions have not been accurately discriminated owing to similarity of materials and paucity of exposures.

Underlying the Cusseta sand at unknown depths, perhaps 300 or 400 feet in the northern part of the county, are Lower Cretaceous deposits which at still greater depths rest upon a basement of crystalline rocks. A well at Fort Valley 1,075? feet deep failed to reach the crystalline rocks. (See No. 3, Table 42.)

The Cretaceous formations are overlain throughout the greater part of the county by Eocene strata, consisting, in ascending order, of the Claiborne group, composed of red, ferruginous, and more or less argillaceous sands and the Jackson formation composed of massive limestones, marls, and calcareous glauconitic clays. Upon the Eocene lies the Vicksburg formation, of Oligocene age, consisting of white limestones, sands, clays, and residual sands and clays with masses of flint. The total thickness of the Eocene and Oligocene formations in the southern part of the county is probably 300 or 400 feet. (See Pl. III, p. 52.)

In relatively narrow areas bordering Ocmulgee River thin terrace deposits of sand, gravel, loam, and clay of Pleistocene age rest upon Cretaceous or Eocene strata

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Water for general domestic purposes is obtained chiefly from dug or bored wells from 40 to 125 feet deep. The waters are commonly soft and of satisfactory quality, although they are more or less strongly mineralized.

Small springs emitting as a rule less than 10 gallons per minute are fairly numerous throughout the greater part of the county, although locally they are reported scarce or absent. In places the spring waters are very soft and are low in mineral content. Norwood Spring, owned by Mrs. J. B. Clarke, of Marshallville, Ga., rises from dark mud in a marsh 1½ miles northeast of Myrtle and is visited by the inhabitants of the surrounding region because of its reputed beneficial qualities. (See analysis 2, Table 43.)

At many places creeks and branch streams are available as sources of supply for the use of domestic animals and for steam making.

Logs of several dug wells are given in the succeeding paragraphs, the owners being the authorities for the lithology.

Log of well of J. W. Epting, 1¼ miles southwest of Powersville (No. 9, Table 42).

	Thickness.	Depth.
Eocene, Claiborne group:	*Feet.*	*Feet.*
Clay	30	30
Upper Cretaceous, Ripley formation:		
"Chalky" [clayey] strata, gradually becoming sandy (some water)	30	60
Clay	25	85
Sandy, "chalky" [clayey] strata, yellowish	23	108
Coarse, white sand, water bearing	2	110

Log of well of T. N. White, 3 miles south of Dunbar (No. 2, Table 42).

	Thickness.	Depth.
Eocene?:	*Feet.*	*Feet.*
Red clay	20	20
Upper Cretaceous, Ripley formation:		
White sand, except two layers of "chalk" [clay] each 1 foot thick, water bearing in lower 3 feet	86	106

Log of well of W. A. Stubbs, 4½ miles east of Wellston (No. 13, Table 42).

	Thickness.	Depth.
Eocene, Claiborne group:	*Feet.*	*Feet.*
Solid red clay	20	20
Upper Cretaceous, Ripley formation, Providence sand member:		
Yellow and white sand, in part fine, alternating with "chalk" [clay], water bearing in sand in lower 3 feet	73	93

Log of well of T. W. Leverett at Wellston (No. 14, Table 42).

	Thickness.	Depth.
	Feet.	*Feet.*
Eocene, Claiborne group:		
Stiff, hard, red clay	40	40
Upper Cretaceous, Ripley formation, Providence sand member:		
Coarse sand with numerous flint rocks [pebbles] as large as end of thumb, water bearing in lower 8 feet	28	68

The Upper Cretaceous sediments which underlie all the county and the Lower Cretaceous strata which lie buried beneath the Upper Cretaceous deposits, the whole aggregating a thickness of more than 1,000 feet, are composed in part of beds of water-bearing sand. Several wells in the county which tap these beds have yielded waters more or less ferruginous, but it is believed that in general the waters are not excessively charged with mineral matter. The wells from which the municipal water supply at Fort Valley is obtained tap water-bearing beds in the Cretaceous deposits.

In the interstream areas in the northern part of the county it is necessary to drill through a relatively thin covering of red ferruginous sand of Eocene age before entering the Cretaceous strata. The Eocene beds thicken southward and in the extreme south it would probably be necessary to drill through 300 or 400 feet of strata of this age to reach the Cretaceous water-bearing beds.

In the southern part of the county beds of sand in the Eocene formations carry moderate amounts of potable water, which should be reached at depths of 50 to 400 feet.

Although no flowing wells have been reported in the county it is probable that flows can be secured in the valley of Ocmulgee River and its tributaries at elevations not exceeding 40 or 50 feet above low-water level.

LOCAL SUPPLIES.

Fort Valley (population 2,697, census of 1910).—The town of Fort Valley is provided with a water-supply system concerning which the following information has been furnished by J. L. Fincher, superintendent of waterworks.

The system, which is owned by the town, is supplied with water from two wells, Nos. 1 and 2, 364 and 400 feet deep, respectively, located at the pumping plant. (See Nos. 4 and 5, Table 42.) Formerly the supply was obtained from a group of seepage springs on the Fagan plantation, 3 miles to the east. The water is lifted to a 50,000-gallon tank by duplex steam pumps having a daily capacity of 450,000 gallons. The length of the distributing mains is 4½ miles. The tank pressure is 42 pounds, and the possible direct pressure from the pumps is 70 pounds. There are 200 taps for domestic purposes, 10 for manufacturing purposes, and 35 fire hydrants. The quantity

of water used daily for domestic purposes is 100,000 to 125,000 gallons and for manufacturing, 50,000 gallons.

The wells are 150 feet apart. The 364-foot well is 8 inches in diameter, and when first drilled an 8-inch casing was inserted to the bottom. A strainer 64 feet long and 6 inches in diameter was inserted from 300 feet to the bottom of the well. The 8-inch casing was then withdrawn 60 feet so that its lower end was just below the top of the strainer. The 400-foot well was constructed in the same manner as the 364-foot well, except that 100 feet of 6-inch strainer was inserted in the lower 100 feet of the well. Because of the greater length of the strainer in the second well it yields more water than does the first well. The wells are not pumped to their full capacity, the yield being more than sufficient to supply the present needs of the town. An analysis of water from the 400-foot well is given in Table 43 (analysis 1).

Logs of the two wells just described were not prepared, but Mr. Fincher states that the material penetrated in the first 25 or 30 feet is red, ferruginous, case-hardened sand, below which the section consists of fine to coarse quartz sand with some thin interbedded layers of clean white clay or kaolin. The sands are for the most part light gray, but some layers are stained yellow or red with iron oxide.

There is at the water plant an old abandoned well said to have been drilled to a depth of 1,075 feet (well No. 3, Table 42). The following is a partial log:[1]

Partial log of well at Fort Valley (No. 3, Table 42).

	Thickness.	Depth.
	Feet.	*Feet.*
Red clay	20	20
Sand	20	40
White clay	8	48
Yellow sand	40	88
White clay	10	98
Quicksand with pebbles	400	498
Hard rock	(?)	(?)
Quicksand.		

Except for the upper 25 or 30 feet, which is probably referable to the Claiborne group of the Eocene, the beds penetrated are of Cretaceous age. The Ripley formation (Cusseta sand member) of the Upper Cretaceous, which immediately underlies the red Eocene stratum at the surface, was probably entirely penetrated, and the underlying Lower Cretaceous deposits were probably penetrated to a depth of several hundred feet. If the depth reached is as great as given (1,075 feet), the bottom of the well is probably very near the basement crystalline rocks.

[1] Georgia Geol. Survey Bull. 15, p. 120, 1908.

Perry (population 649, census of 1910).—Perry, the county seat, owns a water-supply system that obtains water from Indian Creek, a near-by stream. The distributing tank has a capacity of 50,000 gallons. (See analysis 4, Table 43.)

The following record of one well (No. 6, Table 42) at Perry, drilled by the town, has been published by McCallie:[1]

Log of well at Perry (No. 6, Table 42).

	Thickness.	Depth.
	Feet.	*Feet.*
Red massive clay	10	10
White clay	½	10½
Yellowish sand with 4 inches of impervious iron ore at its base	39½	50
Sand, with thin partings of clay	82	132
Dark carbonaceous material—possibly lignite	4	136
Coarse gravel	2	138

An undetermined upper portion of the section is referable to the Claiborne group of the Eocene, and the remainder, the greater part, including the water-bearing gravel at the bottom, to the Providence sand member of the Ripley formation. Zinc, a very unusual constituent of Georgia waters, is reported in the water from this well (No. 3, Table 4). The analysis is old and no more reasonable explanation of this phenomenon presents itself than the doubt that the analysis is correctly reported.

The Southern Mortgage Co., of Atlanta, Ga., owns a 381-foot well (No. 8, Table 42) 4¾ miles southwest of Perry. Detailed information concerning this well was furnished by the S. S. Chandler Artesian Well Co., from whom also the following log was obtained:

Log of well of Southern Mortgage Co., 4¾ miles southwest of Perry (No. 8, Table 42).

	Thickness.	Depth.
	Feet.	*Feet.*
Red clay	69	69
Sand	10	79
Chalk [marl?]	40	119
Yellow sand	20	139
Red clay	11	150
Quicksand	180	330
Marl	20	350
Sand and marl	20	370
Hard rock	6	376
White sand, water bearing	5	381

Water, which rose within 56 feet of the surface, was obtained from the white sand between 376 and 381 feet. The yield was tested with a 4-inch pump for 5 days at 50 gallons per minute; the maximum yield was not determined. An analysis is given in Table 43 (No. 5). The well probably penetrated the basal Eocene strata of this area and entered the upper part of the Ripley formation.

[1] Georgia Geol. Survey Bull. 15, p. 121, 1908.

Other localities.—Detailed information concerning several deep wells is given in Table 42. The water obtained from most wells of this type has proved unsatisfactory. The well at Perry (No. 6, Table 42) is used but little because the water has a strong ferruginous taste. The water of the well 3½ miles west of Wellston (No. 12, Table 42) is satisfactory for drinking and for steam producing, but not for cooking and laundering, probably because of the iron in it. Mr. Smith, the owner, says concerning it:

> The water is not perfectly clear and contains some mineral properties which render it unfit for washing clothes or for cooking. A golden yellow color is imparted to rice or hominy cooked in it, and linens washed in it are turned to a similar color.

The well at Byron, owned by J. H. Peavey (No. 1, Table 42), was abandoned for reasons not given. The following is its log: [1]

Log of well of J. H. Peavey, at Byron (No. 1, Table 42).

	Thickness.	Depth.
Upper Cretaceous:	*Feet.*	*Feet.*
Sands and "chalk" (kaolin)	250	250
Quicksand and "chalk" (kaolin) in 3-foot layers. Water-bearing stratum, coarse sand	60	310

It is probable that all the beds penetrated belong to the Cusseta sand member of the Ripley formation.

TABLE 42.—*Wells in Houston County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Byron	J. H. Peavey		S. W. McCallie [2]	1902	515±
2	Dunbar, 3 miles south of.	T. N. White		Owner	1885	
3	Fort Valley	H. C. Harris		S. W. McCallie [2]		525
4	Fort Valley (well No. 1).	Town	J. L. Fincher	J. L. Fincher	1911	525
5	Fort Valley (well No. 2).	do	do	do	1911	525
6	Perry	Town		S. W. McCallie [2]		
7	Perry, 1 mile east of	D. H. Culler		Owner	1868	On hill.
8	Perry, 4¼ miles southwest of.	Southern Mortgage Co., Atlanta, Ga.	S. S. Chandler Artesian Well Co.	Driller	1911	
9	Powersville, 1½ miles southwest of.	J. W. Epting		Owner	1875	500±
10	Powersville, 1 mile north of.	J. P. Newell		do	1820?	
11	Powersville, 1 mile northeast of.	W. E. Saeger		do	1908	425±
12	Wellston, 3½ miles west of.	J. A. Smith	N. M. Brewer, Dawson, Ga.	do	1903	
13	Wellston, 4½ miles east of.	W. A. Stubbs		do	1890	
14	Wellston (near post office).	Thos. W. Leverett		do		320±

[1] Georgia Geol. Survey Bull. 15, p. 122, 1908. [2] Idem, pp. 120–122.

TABLE 42.—*Wells in Houston County*—Continued.

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute by pumping.	How obtained.	Quality.
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*			
1	310	36	.....	210 275 310	185	50 gallons.....	.....	
2	106	36	103	.....	103	Small	Bucket and rope..	
3	1,075?	4	300	(?)	100	.....	Abandoned.....	
4	364	8	300–364	180	120	100 gallons.....	Air-lift pump.....	Soft.
5	400	8	300–400	180	120	180 gallons.....	.....do.....	Soft; analysis 1, Table 43.
6	138	4	136	.....	42	.....	Hand pump.....	Strongly ferruginous; analysis 3, Table 43.
7	45	48,36	40	.....	.....	Small	Force pump.....	
8	381	4	376–381	.....	56	50+ gallons....	.....do.....	Analysis 5; Table 43.
9	110	36,24	108	60	106	Small	Force pump, gasoline engine.	Soft.
10	109	36	105	.....	103	Small	Bucket and rope..	Do.
11	95	48	95	15	88	Small	.....do.....	Do.
12	216	3	207	180	118	3 to 5 gallons...	Air-lift pump.....	Somewhat ferruginous.
13	93	36	90	.....	90	.....	Bucket and rope..	Slightly ferruginous.
14	68	36	60	58	56–64	Abundant.....	.....do.....	

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Not used.....	Ripley formation (Cusseta sand member).	Coarse sand.....	Cost, $335. Well abandoned; see log, p. 277.
2	Domestic.....	Upper Cretaceous.	.....do.....	Dug. Cribbed in part with wood. Cost, $50. See log, p. 273.
3	Not used.....	Ripley formation..	Sand.....	Well abandoned. See log, p. 275.
4	Municipal supply.	Ripley formation (Cusseta sand member?).	.....do.....	
5	.....do.....	.....do.....	.....do.....	
6	Drinking.....	Ripley formation (Providence sand member).	Coarse gravel.....	Water is little used. See log, p. 276.
7	Domestic.....	.....do.....	Sand.....	Dug. Cost of well, $20; of pump, $60.
8	.....do.....	Ripley formation?.	White sand.....	8-inch casing to 56 feet; 6-inch casing to 330 feet; 4-inch casing to 381 feet. See log, p. 276.
9	.....do.....	Cusseta sand.....	Coarse white sand.	Dug. Cost of well, $100; of pump, $250. See log, p. 273.
10	.....do.....	.....do.....	.....do.....	Dug. Cribbed in part with wood.
11	.....do.....	.....do.....	Sand.....	Dug. Cribbed in part with wood. Cost, $60.
12	Boiler and drinking.	Upper Cretaceous.	Sand.....	Drilled. Length of casing, 207 feet. Cost of well, $300; of pump, $300. Unfit for laundry and cooking.
13	Domestic.....	Ripley formation (Providence sand member).	.....do.....	Dug. Cribbed 75 feet. Cost, $40. See log, p. 273.
14	.....do.....	.....do.....	Coarse pebbly sand.	Dug. Cost, $45. See log, p. 274.

TABLE 43.—*Analyses of underground waters from Houston County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	May 20, 1911	Town well No. 2.	Fort Valley	Ripley formation (Cusseta sand member?).	400	Edgar Everhart.
2	.....do.....	Norwood Spring	Myrtle (1½ miles northeast of).	Ripley formation (Providence sand member?).	.....	Do.
3	.....	Town well.....	Perry.....	Ripley formation (Providence sand member).	136–138	W. H. Hollingshead.[a]
4	May 5, 1911	Big Indian Creek.	Near Perry.....	.....	.....	Edgar Everhart.
5	May 30, 1911	Well of Southern Mortgage Co.	Perry (4½ miles southwest of).	Ripley formation?	376–381	Do.

No.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Remarks.
1	29	3.0	.....	2.0	1.0	5.0	0.0	12	5.0	0.5	5.0	63	Well 5, Table 42.
2	5.5	1.5	.....	2.0	1.0	3.0	.0	10	7.0	.2	5.0	40	
3	8.5	5.5	2.8	4.4	1.3	[b]6.1	.....	.....	7.8	.....	2.2	[c]57	Well 6, Table 42.
4	15	.6	.....	3.0	1.0	3.0	.0	15	Tr.	1.5	3.5	52	
5	10	2.0	.....	4.0	1.0	4.0	.0	24	9.0	Tr.	4.5	43	Well 8, Table 42.

[a] Georgia Geol. Survey Bull. 15, p. 121, 1908.
[b] Trace of potassium.
[c] Phosphate radicle (PO_4) 2.1; zinc (Zn) 9.4; lithium (Li) trace.

IRWIN COUNTY.

GENERAL FEATURES.

Irwin County is in the central part of the Coastal Plain of Georgia, about midway between the Atlantic coast and the western boundary of the State. Its area is 378 square miles and its population is 10,461 (census of 1910). Lumbering and agriculture are the principal industries.

TOPOGRAPHY.

The county is nearly level to gently rolling. The streams are small, have broad shallow valleys, and flow sluggishly through wide swamps. Small cypress ponds and bays are numerous.

GEOLOGY.

The surface terrane throughout practically the whole county consists of 50 feet or less of irregularly bedded argillaceous sands and sandy clays which weather to loose gray sands. The surficial deposits

are underlain by the Alum Bluff formation, which consists of 100 to 150 feet of sands and clays which outcrop only in one or two very small areas near the southern boundary of the county. The Alum Bluff formation is underlain by undifferentiated limestones, sands, clays, and marls, in descending order of Oligocene, Eocene, and Cretaceous age, probably having an aggregate thickness of several thousand feet. The Cretaceous deposits are believed to rest upon a deeply buried basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug wells 10 to 40 feet deep are the main source of domestic water supply. Springs are few and of slight importance.

Artesian water can be obtained anywhere at depths of 200 to 1,000 feet or more. The static head will probably nowhere be great enough to produce flows.

LOCAL SUPPLIES.

Ocilla (population 2,017, census of 1910).—Ocilla owns a public water-supply system, which draws from an artesian well. The well was completed in 1906, is 355 feet deep, and 8 inches in diameter. The principal water-bearing bed is near the bottom; the water, which rises to within 98 feet of the surface, is lowered 8 feet by pumping. The water is used for domestic purposes and for the boiler supply of several cotton gins and one sawmill. The water-bearing stratum is probably in the Vicksburg formation of the Oligocene. The following analysis of a sample of water from this well, collected April 4, 1911, is by Edgar Everhart:

Analysis of water from the 355-foot town well at Ocilla.

	Parts per million.
Silica (SiO_2)	18
Iron (Fe)	1.5
Calcium (Ca)	34
Magnesium (Mg)	6.2
Sodium and potassium (Na+K)	5.6
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	158
Sulphate radicle (SO_4)	Trace.
Nitrate radicle (NO_3)	Trace.
Chlorine (Cl)	4.5
Total dissolved solids	144

The water is clear, emits a slight odor of hydrogen sulphide, and is suitable for general domestic purposes.

The following information on a deep well at the lumber mill of the Ensign Oskamp Co. is given by McCallie:[1]

[1] Georgia Geol. Survey Bull. 15, pp. 123, 124, 1908.

This well, which was put down in 1900 at a cost of $1,200, is 6 inches in diameter and 512 feet deep. The water rises to within 40 feet of the surface, but by continuous pumping it is lowered to 120 feet. The maximum yield is 35 gallons per minute. The water is used with surface water, after being treated with boiler compound, for steam purposes. Water-bearing strata are reported at 312 and 496 feet, respectively.

The following record of the well is from memory:

[*Log of well at mill of Ensign Oskamp Co., at Ocilla.*]

	Feet
Soil and clay	0– 60
Soft rock	60– 76
Sand	76–105
Rock	105–300
Very hard rock	300–312
Porous limestone with cavities 4 feet deep	312–512

JEFF DAVIS COUNTY.

GENERAL FEATURES.

Jeff Davis County is in the central part of the Coastal Plain of Georgia in the long-leaf pine or wire-grass section. Its area is 300 square miles and its population is 6,050 (census of 1910). Agriculture, lumbering, and turpentining are the principal industries. The county is sparsely settled and Hazelhurst, the county seat, is the only town of importance.

TOPOGRAPHY.

Over the greater part of the county the surface is nearly level to slightly rolling. Altamaha River and its tributary, Ocmulgee River, which form the northern boundary, have cut their valleys 150 to 200 feet below the upland level to the south; the Southern Railway track at Hazelhurst is approximately 170 feet higher than the low-water level at Lumber City. Altamaha and Ocmulgee rivers are bordered by two Pleistocene terrace plains, one lying 10 to 20 feet and the other 40 to 50 feet above low-water level. These plains are better developed on the north side of the valley than on the south side in Jeff Davis County, where in many places they are narrow or absent. Throughout its extent along the northern border of the county the river valley is separated from the upland to the south by an abrupt escarpment.

The interstream areas are poorly drained, and small cypress ponds and bays characterize the topography. The elevation above sea level at Hazelhurst, the county seat, is 256 feet.

GEOLOGY.

The surface deposits throughout the entire county, except in a few relatively small areas in the north, consist of 100 feet or less of irregularly bedded sandy clays and sands, with subordinate, inter-

bedded layers of argillaceous sandstone and quartzite. They are underlain by 100 feet or more of soft sandy clays and sands with interbedded thin layers of sandstone and quartzite belonging to the Alum Bluff formation, which outcrops in the bluffs of Ocmulgee and Altamaha rivers. Pleistocene terrace sands and clays have been laid down in narrow areas bordering Ocmulgee and Altamaha rivers.

The Alum Bluff formation is underlain in descending order by a series of undifferentiated limestones, sands, clays, and marls of Eocene and Cretaceous age, probably aggregating several thousand feet in thickness, which contain important water-bearing beds. In an oil-prospecting well 8 miles southwest of Hazelhurst, water-bearing limestones which may represent in descending order the Chattahoochee and Vicksburg formations (Oligocene) and the Jackson formation (Eocene) were penetrated from 400 to 815 feet. At an undetermined depth the Cretaceous deposits rest upon a basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The main sources of domestic water supply throughout the county are dug wells 15 to 60 feet deep. The waters of the shallow wells are derived from beds of sand that are either surficial or belong to the underlying Alum Bluff formation. The waters are soft and if protected from surface contamination are of satisfactory quality for domestic purposes.

Springs are small and few and are unimportant. Ponds and streams are utilized for stock and for boiler supply.

Artesian water can probably be obtained anywhere and flowing wells are possible on the terraces bordering Altamaha and Ocmulgee rivers.

LOCAL SUPPLIES.

Hazelhurst (population 1,181, census of 1910).—Hazelhurst, the county seat, is on the flat divide between Ocmulgee and Satilla rivers 256 feet above sea level. The water supply of the town is derived from a public artesian well and from shallow dug wells owned by individuals.

The public well (No. 3, Table 44), completed in 1911, is 643 feet deep and 8 inches in diameter. The water is reported to be derived from cavernous limestone below 482 feet, to which depth the casing extends, and to rise to within 171 feet of the surface. A small yield of water was obtained from a pebble bed at 140 feet, and a second supply at about 460 feet. The static head is said to be lowered 20 feet when the well is pumped continuously 125 gallons per minute. The water is hard, clear, and colorless, has a faint odor, and has

proved satisfactory for domestic use. The limestone from which the water is derived is referable questionably to the Vicksburg formation. A sample collected April 6, 1911, was analyzed by Edgar Everhart with the following results:

Analysis of water from the public artesian well, Hazelhurst (No. 3, Table 44).

	Parts per million.
Silica (SiO_2)	24
Iron (Fe)	.4
Calcium (Ca)	52
Magnesium (Mg)	4.0
Sodium and potassium (Na+K)	18
Carbonate radicle (CO_3)	2.5
Bicarbonate radicle (HCO_3)	178
Sulphate radicle (SO_4)	9.0
Chlorine (Cl)	9.5
Nitrate radicle (NO_3)	Trace.
Total dissolved solids	231

Another well at Hazelhurst, near the bottling works, is reported to be between 400 and 500 feet deep and to tap a water-bearing bed at about 400 feet.

Three oil-prospecting wells 8 or 9 miles southwest of Hazelhurst have been drilled by Mr. L. F. Hinson, but only meager data have been obtained concerning them. In one well 828 feet deep, on the Hinson farm, water rises to within 125 feet of the surface. One of the drillers has furnished the following log:

Log of oil-prospecting well 8 miles southwest of Hazelhurst (No. 5, Table 44).

	Thickness.	Depth.
	Feet.	*Feet.*
Surface clay and sand	25	25
Soft clayey sand	200	225
Bluish clay and sand	175	400
Hard rock (limestone), shells at top	15	415
Principally limestone	400	815
Black sandstone	13	828

Goldsmith.—At Bird's turpentine distillery near Goldsmith a well was drilled to 700 feet. Gas is reported to have been found at a depth of 550 feet.

On the bank of Hurricane Creek near Goldsmith and about three-quarters of a mile north of the Georgia & Florida Railway trestle is a well 300 feet deep, the water of which is said to stand within a few feet of the surface.

TABLE 44.—*Wells in Jeff Davis County.*

No.	Location.	Owner.	Authority.	Date completed.	Approximate elevation above sea level.	Depth.	Diameter.
					Feet.	*Feet.*	*Inches.*
1	Goldsmith, near					700	
2	Goldsmith (on Hurricane Creek).					300	
3	Hazelhurst	City		1911	256±	643	8
4	do	Bottling works				400	
5	Hazelhurst (8 or 9 miles southwest of).	L. F. Hinson	Well driller			828	

No.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	How obtained.	Horizon of principal water bed.	Remarks.
	Feet.	*Feet.*	*Feet.*			
1						Gas reported at 550 feet.
2						Water rises within a few feet of the surface.
3	482–643	140, 460	171	Pumped	Vicksburg formation?	City supply. See analysis, p. 283.
4	400				do	
5			128			Oil-prospecting well; see log, p. 283. Two other oil-prospecting wells have been drilled in vicinity.

JEFFERSON COUNTY.

GENERAL FEATURES.

Jefferson County is in the northeastern part of the Coastal Plain of Georgia, between Oconee and Savannah rivers, 12 to 15 miles south of the fall line. Its area is 720 square miles and its population 21,379 (census of 1910). Agriculture and the production of lumber are the principal industries.

TOPOGRAPHY.

The northern part of the county, which lies within the physiographic division known as the fall-line hills, is somewhat broken or hilly, and the interstream areas are thinly covered with residual gray sand. The southern part contains nearly level areas underlain by limestone and characterized in places by lime sinks and ponds. The county is drained chiefly by Ogeechee River and its tributaries.

In the north the interstream areas lie about 500 feet above sea level. The upland surface inclines slightly southward, descending to about 300 to 350 feet above sea level in the southern part of the county. At the junction of Williamsons Swamp creek with Ogeechee River in the extreme southeast the elevation above sea level is about 200 feet.

GEOLOGY.

The Claiborne group of the Eocene, which appears at the surface throughout the greater part of the county, has been subdivided into two formations, the McBean formation and the Barnwell sand. The McBean formation consists of 300 to 400 feet of sands, clays, marls, and limestones containing important water-bearing beds; the Barnwell sand, which overlies the McBean formation, consists of 100 feet or less of red sands with interbedded thin layers of sandstone and gravel.

In the southwest, south of Williamsons Swamp creek, the Claiborne group is overlain by a small thickness of irregularly bedded sands and clays of undetermined age. The Claiborne group is underlain by 500 to 1,000 feet of irregularly bedded sands and clays of Cretaceous age, which contain numerous water-bearing beds and constitute an important source of artesian waters in the region; these beds appear at the surface only in a few small areas in the northwest.

The Cretaceous deposits rest upon a basement of ancient crystalline rocks which lie at depths of 200 to 300 feet in the north but descend to probably 1,200 to 1,500 feet in the extreme south. In the oil-prospecting well 3½ miles southwest of Louisville (see p. 287) the basement rocks were struck at 1,140 feet.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Wells ranging in depth from 25 to 75 feet are the chief source of domestic water supply, and where protected from surface contamination they yield waters of good quality. In the southern part there are limestone springs of considerable size, and in the hilly area in the north small springs are common. Springs, however, are not extensively utilized. An analysis of water from Omaha Spring, near Avera, collected June 3, 1911, is given in Table 46 (analysis 1).

Although Cretaceous deposits appear at the surface only in small areas along the extreme northwestern boundary, they can be reached throughout the remainder of the county by drilling through from 100 to 500 feet of overlying Eocene strata. As they contain numerous beds of porous sand abundant supplies of water should be obtained from them. The water-bearing beds would be tapped at 100 to 300 feet in the extreme north and at 400 to 1,200 feet or more in the extreme south. The static head of the water in the Cretaceous deposits in the valleys of Ogeechee River and its tributaries in the central and southern parts of the county should be great enough to produce flows.

Water-bearing beds of sand in the Claiborne group are tapped at 50 to 100 feet in the north and at 50 to 500 feet in the south. Flowing wells are obtained from the Claiborne group in the valleys of Ogeechee River and its tributaries in the southern part of the county.

LOCAL SUPPLIES.

Louisville (population 1,039, census of 1910).—At Louisville shallow dug wells are the chief source of domestic water supply, though artesian wells are owned by several residents. The town has no system of waterworks. An analysis of water from an artesian well at the fair grounds is given in Table 46 (analysis 2).

McCallie[1] gives the following information concerning wells at Louisville:

There are five artesian wells in or near Louisville varying in depth from 350 to 450 feet. Water-bearing strata were struck in these wells at 200 and 300 feet, the main water supply being obtained from the latter stratum. Only those wells which are located on low ground furnish a flow.

The following notes on the strata penetrated in putting down the Louisville deep wells were obtained from Mr. G. H. Harrell of Louisville:

[*General log of wells in and near Louisville* (*No. 3, Table 45*).]

	Feet.
Red motley clays	25
Fine yellow sand	40
Quicksand	6
Marl, with fragments of shell	8
Blue marl	100
Flint	0.5
Marl, honeycombed rock, and lignite	100
Coarse sand with mica	(?)

In addition to the wells above noted, there is also another well located at a water station, 2 miles south of Louisville, on the Louisville & Wadley Railroad. This is a 4-inch well, 325 feet deep, and it furnishes 20 gallons of water per minute. Two water-bearing strata were struck in this well, one at 150 and the other at 300 feet from the surface. The former furnishes only a small flow, while the water from the latter rises 20 feet above the surface.

An oil-prospecting well (No. 5, Table 45) 3½ miles southwest of Louisville completely penetrates the deposits of the Coastal Plain, including the Cretaceous and Eocene strata. Although the facts recorded furnish no direct information as to the character of the water-bearing strata encountered, the log of the well is instructive on account of the light which it throws on the structure of the region. The log, as furnished to McCallie[2] by James Tague, contractor, is as follows:

[1] Georgia Geol. Survey Bull. 15, pp. 125, 126, 1908. [2] Idem, pp. 128–131.

Log of oil-prospecting well 3½ miles southeast of Louisville (No. 5, Table 45).

	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Mixed clay and sand	68	8	68	8
Sand and rock	6	0	74	8
Blue clay	2	0	76	8
Blue clay and sand	14	7	91	3
Blue clay	2	0	93	3
Sand	3	0	96	3
Hard rock		8	96	11
Soft sand rock	2	4	99	3
Sand	13	10	113	1
Hard rock	1	1	114	2
Sand	2	0	116	2
Soft rock	3	0	119	2
Hard rock	1	0	120	2
Blue clay	12	3	132	5
Sand rock	10	0	142	5
Sand and clay	8	0	150	5
Blue clay	18	7	169	0
Sand	2	0	171	0
Blue clay and shale	5	0	176	0
Hard rock	1	7	177	7
Blue clay and sand layers	7	0	184	7
Hard rock	4	4	188	11
Sand	15	5	204	4
Hard rock	1	6	205	10
Blue and white clay	3	0	208	10
Hard rock		8	209	6
Sand	4	0	213	6
Shale	6	3	219	9
Sand	4	0	223	9
Blue clay and shale	45	9	269	6
Fine sand	6	0	275	6
Clay and shale	22	6	298	0
Fine sand	9	10	307	10
Sand	198	0	505	10
Red clay	4	7	510	5
Red and white clay	22	6	532	11
Red clay	29	3	562	2
Sand	19	4	581	6
White clay	2	4	583	10
Hard clay		8	584	6
Clay	4	0	588	6
Sand with gas	10	7	599	1
Sand with hard layers	62	5	661	6
Mixed clay	4	0	665	6
Sand	38	10	704	4
Mixed clay	37	2	741	6
Sand	10	0	751	6
Clay	8	1	759	7
Sand	16	0	775	7
Tough clay	8	0	783	7
Sand	14	8	798	3
Hard layer		2	798	5
Sand	2	5	800	10
Sandy clay	42	2	843	0
Sand	10	0	853	0
Mixed clay	17	8	870	8
Sand	26	3	896	11
Mixed clays	16	5	913	4
Sand	16	0	929	4
Clay	19	3	948	7
White and yellow sand	6	9	955	4
White clay	10	0	965	4
Sand	11	0	976	4
Shale	3	7	979	11
Clay	19	2	999	1
Sand	2	0	1001	1
Clay	5	0	1006	1
Hard layer		10	1006	11
Blue clay	20	7	1027	6
Sand	8	0	1035	6
Clay	16	6	1052	0
Sand	6	0	1058	0
Shale	4	0	1062	0
Sand	6	9	1068	9
Clay	20	0	1088	9
Clay and shale	22	3	1111	0
Very hard shale	22	2	1133	2
Cemented gravel	7	0	1140	2
Hard rock	3	0	1143	2

Fossils characteristic of the Claiborne group of the Eocene were obtained at 250 feet. A fragment of a turtle supposed to be of Upper Cretaceous age was obtained at 380 feet. On the basis of these fossils the contact between the Cretaceous and Eocene deposits is here placed tentatively between 250 and 380 feet. Diorite gneiss, encountered at 1,140 feet, doubtless represents the rock of the crystalline basement on which the deposits of the Coastal Plain rest. The probable total thickness of Cretaceous strata penetrated is therefore 790 feet. The Upper and Lower Cretaceous strata, both of which are believed to be represented in the section, could not be differentiated.

Wadley (population 872, census of 1910).—The town has no public water-supply system, but has about 15 artesian wells, owned by individuals, which range in depth from 300 to 500 feet and flow 3 to 15 feet above the surface. Although the waters are moderately hard and emit strong odors of hydrogen sulphide they are potable. An analysis of water from one of the artesian wells is given in Table 46 (No. 4). McCallie [1] has published, on the authority of M. M. Caldwell, the following log of an artesian well at Wadley:

Log of artesian well at Wadley.

	Thickness.	Depth.
	Feet.	*Feet.*
Yellow clay	60	60
Blue marl	100	160
Sand	2	162
Marl and limestone	250	412
Sand.		

Bartow (population 384, census of 1910).—Bartow is in the southern part of the county on a terrace plain a few feet above the swamp of Williamsons Swamp creek and 237 feet above sea level. The town has no system of waterworks, and water is obtained from artesian and shallow wells owned by individuals. The artesian wells range in depth from 160 to 525 feet and most of them flow small streams. They tap water-bearing strata in the Claiborne group (McBean formation) of the Eocene. McCallie [2] has published the following log of a well at Bartow, prepared from memory by L. B. Clay, the driller:

[1] Georgia Geol. Survey Bull. 15, pp. 126, 127, 1908. [2] Idem, pp. 127–128.

Log of deep well at Bartow (No. 2, Table 45).

	Thickness.	Depth.
	Feet.	*Feet.*
Red, sandy clays	12	12
Coarse gravel (?)	40	52
Marl and sand (water bearing)	60	112
Blue marl with an occasional layer of rock	250	362
Same as above, with sharks' teeth and shells	163	525

Spread (population 370, census of 1910).—Spread is in the northern part of the county on the Augusta Southern Railroad. Its exact elevation above sea level is not known but is thought to be approximately 400 feet. The town owns an artesian well which, according to Mayor J. L. Denton, is 130 feet deep and taps a white water-bearing sand at the bottom. The water, which is soft but ferruginous, comes either from the base of the Claiborne group or from the upper part of the Cretaceous, and rises to within 16 feet of the surface. It is pumped to an elevated tank having a capacity of 1,300 gallons, from which it is distributed to the consumers. The system is, however, inadequate and furnishes only a portion of the domestic supply. (See Table 46, analysis 3.)

Most of the water supply for domestic purposes is obtained from wells averaging about 30 feet in depth.

Wrens (population 616, census of 1910).—McCallie[1] has published the following data concerning a well at Wrens:

> This well, which belongs to Mr. W. J. Wren, is located within a few hundred feet of the railway station. It is 4 inches in diameter and 556 feet deep, and it furnishes a maximum yield of 80 gallons per minute. The principal water-bearing stratum is at 525 feet from the surface, and the water rises to within 20 feet of the surface. It is used for general domestic and boiler purposes. This well was put down in 1897 at a cost of $400.

The well just described taps a water-bearing bed at 525 feet in Cretaceous strata that were probably entered at about 175 feet. (See Table 46, analysis 5.)

[1] Georgia Geol. Survey Bull. 15, p. 128, 1908.

TABLE 45.—*Wells in Jefferson County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Avera	Thos. S. Ivey	John F. Brassell.	Thos. S. Ivey	1909	
2	Bartow			S. W. McCallie[a]		237
3	Louisville			do		
4	Louisville, 2 miles south of.	Louisville & Wadley R. R. Co.		do		
5	Louisville, 3½ miles southwest of.			do		
6	Louisville (old town)			do		
7	Spread	Town		J. L. Denton, mayor, and David Denton.	1907	400
8	Wadley			S. W. McCallie[a]		243
9	Wrens	W. J. Wren		W. W. Burnham[a]	1897	

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	54				−52			Pumped	
2	160–525			60 225 350	+7–10			Flows	
3	350–450		300	200				Both flowing and nonflowing.	Sulphurous; analysis 2, Table 46.
4	325	4	300	150	+20			Flows	Sulphurous.
5	1,143								
6	225?		200	160	+28			Flows	
7	130	4			−16		65	Pumped; gasoline engine.	Soft; analysis 3, Table 46.
8	330–500			170, 330	+3–15			Flows	Hard, sulphurous; analysis 4, Table 46.
9	556	4	525		−20		80		Aanalysis 5, Table 46.

No.	Use.	Principal water bed.—		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Claiborne group?		Dug well, 2 feet square.
2	Domestic, stock	McBean formation		3 or more wells in vicinity. See log, p. 289.
3	Domestic	McBean formation?		5 wells in vicinity. See log, p. 286.
4	Boiler supply of locomotives.	do		
5				Oil-prospecting well. See log, p. 287.
6		McBean formation		
7	Domestic	Cretaceous?	Sand and gravel	4-inch casing to bottom. Cost of well, $450.
8	Domestic, boiler supply of locomotives.	McBean formation?		Several wells. See log, p. 288.
9	Domestic, boiler supply.	Cretaceous		Cost $400.

[a] Georgia Geol. Survey Bull. 15, pp. 125–131, 1908.

TABLE 46.—*Analyses of underground waters from Jefferson County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	June 3, 1911	Omaha Spring..	Avera.....	Claiborne group.	.....	Edgar Everhart.
2	.....	Well at the fair grounds.	Louisville.....	McBean formation.	200-300	Do.[a]
3	Dec. 18, 1912	Town well.....	Spread.....	Cretaceous?.....	130	Do.
4	.....	Artesian well....	Wadley.....	McBean formation?	170-330	Do.[a]
5	May 8, 1911	Well of W. J. Wren.	Wrens.....	Cretaceous.....	525	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Remarks.
1	5.0	0.4	1.0	1.0	2.0		0.0	8.0	1.0	4.0	4.0	20	
2	39	[b]4.1	33	1.4	3.1	2.8	47	.....	9.4	.....	8.2	152	PO_4, 3.3 parts, well 3, Table 45.
3	12	8.0	4.0	1.0	6.0		.0	22	2.0	.....	4.0	58	Well 7, Table 45.
4	13	[b]1.8	57	3.1	8.9	3.0	.0	191	11	.....	4.7	191	PO_4, trace; free CO_2, 13; well 8, Table 45.
5	49	2.0	28	1.0	12		.0	102	8.0	.2	8.0	178	Total depth, 556 feet; well 9, Table 45.

[a] Georgia Geol. Survey Bull. 15, pp. 125-127, 1908. [b] $Fe_2O_3+Al_2O_3$.

JENKINS COUNTY.

GENERAL FEATURES.

Jenkins County is in the northeastern part of the Coastal Plain of Georgia. Millen, the county seat, is 53 miles south of Augusta. The area of the county is 342 square miles and its population is 11,520 (census of 1910). Agriculture and the shipment of lumber and naval stores are the principal industries. A cotton-cloth factory and a few small manufacturing plants are located at Millen.

TOPOGRAPHY.

The greater part of the county is rolling to slightly hilly. West and northwest of Millen, however, the land is nearly level with a few lime sinks. Ogeechee River flows across the county and is bordered by a wide swamp and by a higher terrace plain. The known elevations at railroad stations are Millen, 158; Lawtonville, 225; Perkins, 252 (?); Paramore, 244; Scarboro, 157; Rogers, 162; and Herndon, 189. Some land in the eastern part of the county probably rises to 300 feet.

GEOLOGY.

The surface terrane over the eastern and southern parts of the county consists of 50 feet or less of irregularly bedded, locally indurated sands and clays of undetermined but probably upper Oligocene age.

These are underlain by the Alum Bluff formation, which consists of 75 to 100 feet of sands and clays similar to and not easily discriminated from the overlying deposits and which outcrops in the valley slopes of Ogeechee River and its tributaries. The formation contains water-bearing beds.

The Alum Bluff formation is underlain by limestones and marls which probably represent in descending order the Chattahoochee and Vicksburg formations of the Oligocene and the Jackson formation of the Eocene. The limestone that comes to the surface in an area of considerable extent northwest of Millen is mapped provisionally as Chattahoochee formation. The thickness of the limestones and marls is not known but probably amounts to not less than 250 feet. The limestones and marls, which are water bearing, supply shallow wells and are the source of several bold springs. The Claiborne group of the Eocene, which consists of 300 to 500 feet of sands, clays, and marls, underlies the undifferentiated limestones and marls of the Oligocene and upper Eocene; although the strata of the Claiborne group do not appear at the surface in the county they are abundantly water bearing and have been tapped by a dozen or more wells.

The Claiborne group is underlain by a series of sedimentary deposits of Cretaceous age, probably 1,000 feet or more in thickness, and these in turn rest upon a deeply buried basement of ancient crystalline rocks. The Cretaceous deposits are water bearing and in the valley of Ogeechee River should yield strong flows.

Thin terrace deposits of sand and clay of Pleistocene age border Ogeechee River and rest upon the older formations.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

In the rural districts water for domestic use is obtained principally from dug wells 20 to 60 feet deep. Small seepage springs are common and yield soft waters. A mineral analysis of the water of Jones Spring, a small seepage spring a mile east of Thrift, is given in Table 48 (analysis 3). In the western part of the county there are a few bold limestone springs. Magnolia Spring, 6 miles north of Millen, yields several million gallons daily of hard sulphurous water.

Artesians wells have been drilled at Millen, Rogers, Herndon, Perkins, and Scarboro. Although artesian water can probably be obtained anywhere in the county at depths of 300 to 600 feet or more, the area of flowing wells will probably be restricted to narrow belts of lowland bordering Ogeechee River and Buckhead Creek.

LOCAL SUPPLIES.

Millen (population 2,030, census of 1910).—The public water supply of Millen is derived from an artesian well, and several such wells are owned by individuals. The wells range in depth from 320 to 565 feet, and all of them flow 3 to 20 feet above the surface. Water-bearing strata, probably belonging to the Claiborne group, are encountered at depths of 260, 300, 390, and 444 feet. The yield from the 444-foot stratum is said to be approximately 100 gallons per minute. The artesian water emits a strong odor of hydrogen sulphide and is moderately hard but clear and wholesome. (See Table 48, analysis 1.)

Perkins.—At Perkins there are three artesian wells, one of which, owned by Dr. W. E. Rushing, is 500 feet deep. The other two are about 300 feet deep. The principal water supply is from rock and sand at about 300 feet and the water rises to within 17 feet of the surface. An analysis of the water from Dr. Rushing's well is given in Table 48 (analysis 2). Wells 20 to 60 feet deep and yielding soft waters are common.

Herndon.—Herndon is on the terrace bordering Ogeechee River in the extreme western part of the county. Several fine artesian wells in the vicinity are from 200 to 500 feet deep. One well (No. 1, Table 47), owned by J. B. Jones and drilled in 1906, is 364.5 feet deep and flows 360 gallons a minute; its static head is 40 feet above the surface. The following log has been prepared from a set of well borings furnished by H. F. Loyd, the driller, which are on file in the office of the United States Geological Survey (well No. 1306), and from the driller's log:

Log of well of J. B. Jones, Herndon (No. 1, Table 47).

	Thickness.	Depth.
	Feet.	*Feet.*
Not reported	40	40
Soft white limestone with sand at base which yielded a flow of 10 gallons a minute	125	165
Fine light-gray, loose calcareous sand	25	190
Light bluish-gray, finely arenaceous, calcareous clay or marl, interbedded with thin layers of gray calcareous sandstone containing Bryozoa and numerous fragments of shells	150	340
White sandy limestone, soft at bottom, with numerous fragments of shells; yielded a flow of 20 gallons a minute	7	347
Coarse water-bearing sand containing much lignite and numerous invertebrates, including Dendrophyllia, Trigonoarca, Ostrea, Pecten, *Venericardia planicosta?*, *Cytherea perovata* Conrad, Turritella	17.5	364.5

The fossils from the lowest layer were identified by T. W. Vaughan, who correlates the containing bed with the Claiborne group of the Eocene and probably with the McBean formation of that group.

The artesian water at Herndon is considered hard, but that of the shallow wells is soft.

The following partial log has been prepared from well borings on file in the office of the United States Geological Survey (well No.

1565), furnished by H. F. Loyd, taken from a well (No. 3, Table 47), owned by Mrs. E. Daniel, 5 miles north of Herndon. It is not known whether the samples represent the total depth of the well.

Partial log of well of Mrs. E. Daniel, 5 miles north of Herndon (No. 3, Table 47).

	Thickness.	Depth.
	Feet.	*Feet.*
Missing	40	40
White sandy limestone with numerous fragments of shells	95	135
Light bluish-gray fine, very calcareous sand or marl, partly indurated	208	343
Mixture of fragments of white limestone (one showing dendritic growth), blue calcareous sandstone, quartz grains, and fragments of shells; recognized Bryozoa, Balanus, and a fragment of Turritella		343

Rogers.—At Rogers water is obtained from both shallow dug wells and deep artesian wells. McCallie[1] states that one well (No. 8, Table 47) is 351 feet deep and 4 inches in diameter and flows 80 gallons a minute; the water rises 24 feet above the surface. He published the following log of this well on authority of H. M. Loyd:

Log of well at Rogers (No. 8, Table 47).

	Thickness.	Depth.
	Feet.	*Feet.*
Blue clay	5	5
Fine white sand	55	60
Blue marl	120	180
Black sand (water bearing)	2	182
Blue marl and rock; last 50 feet soft rock	169	351

Scarboro.—Scarboro is in the southeastern part of the county on the terrace bordering Ogeechee River, at an elevation of approximately 157 feet above sea level. A well (No. 9, Table 47) owned by M. C. Sharpe, drilled in 1902, is 505 feet deep and yields water that rises to within 15 feet of the surface. McCallie[2] has published the following log:

Log of well of M. C. Sharpe, Scarboro (No. 9, Table 47).

	Thickness.	Depth.
	Feet.	*Feet.*
Sand	4	4
Blue marl	100	104
Soft rock with cavities	40	144
Hard rock at 200 feet extending to bottom of well	361	505

[1] Georgia Geol. Survey Bull. 15, p. 65, 1908.
[2] Idem, pp. 162-163, 1908.

TABLE 47.—*Wells in Jenkins County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Herndon	J. B. Jones	H. F. Loyd	H. F. Loyd	1906	189
2	do	do	do	S. W. McCallie[a]		189
3	Herndon (5 miles north of).	Mrs. E. Daniel	do	H. F. Loyd and E. Daniel.		
4	Millen					157
5	Perkins	W. E. Rushing	H. F. Loyd	W. E. Rushing	1907	252
6	do	J. A. Rodgers	J. F. Loyd	J. S. Lake	1909	252
7	Rogers	W. M. Wadley		Postmaster	1886	159
8	do		H. M. Lloyd	S. W. McCallie[a]		159
9	Scarboro	M. C. Sharpe	H. F. Loyd	do[a]	1902	147

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	364.5	4	347	160	+40	360		Flows	
2	300	2	300		+14	30		do	Hard.
3	343?				−30				Soft.
4	320–565		444	260, 300, 390	+3–20	100		Flow	Analysis 1, Table 48.
5	500	3	300±		−17				Analysis 2, Table 48.
6	300	8	300		−17			Steam engine	Hard.
7	410	4			+18			Flows	Do.
8	351	4	330	180	+24	80		do	
9	505	4	375	180, 300	−15				

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Claiborne group	Rock	4-inch casing to 255 feet. Cost of well, $475. See log, p. 293.
2		do	Porous limestone	
3	Domestic	Jackson formation?		Cost of well, $300. See log, p. 294.
4	Domestic and manufacturing.	Claiborne group	Rock	Data relate to several wells.
5	Domestic	do	Rock and sand	3-inch casing to 155 feet. Cost of well, $250; of pump, $15.
6	Domestic and boiler supply.	do		Cost of well, $250.
7	Domestic	do		
8	do	do	Blue and marl rock	See log, p. 294.
9	do	do		Cost of well, $650. See log, p. 294.

[a] Georgia Geol. Survey Bull. 15, pp. 64–65, 162, 1908.

TABLE 48.—*Analyses of underground waters from Jenkins County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	.....	Artesian well....	Millen.....	Claiborne group.	320–565	Edgar Everhart.[a]
2	June 3, 1911	Well of W. E. Rushing.	Perkins.....	.....do.....	300±	Do.
3	.....	Jones Spring	Thrift, 1 mile east of.	Surface deposits.	.....	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Remarks.
1	38	[b]1.2	40	3.6	5.6	2.4	.....	132	11	.....	8.0	175	Wells 4, Table 47.
2	11	.5	64	1.0	4.0		0.0	183	26	0.2	6.0	200	Total depth, 500 feet; well 5, Table 47.
3	6.0	.8	2.5	.6	5.9	.4	.....	28	1.8	.....	8.9	34	

[a] Georgia Geol. Survey Bull. 15, p. 160, 1908.

[b] $Fe_2O_3+Al_2O_3$.

JOHNSON COUNTY.

GENERAL FEATURES.

Johnson County is in the northeastern part of the Coastal Plain of Georgia. Its area is 292 square miles and its population 12,897 (census of 1910). Agriculture is the principal industry.

TOPOGRAPHY.

The eastern part is gently rolling, the topography being that characteristic of the Altamaha upland or wire-grass section. The valleys are shallow, the slopes are low and gentle, and the clear streams flow through broad swamps. The western part is drained by Oconee River and is somewhat broken and hilly.

No determinations of altitude have been made, but from estimates based on established altitudes at Dublin, Laurens County, and Oconee, Washington County, the level of Oconee River in Johnson County is thought to be 180 to 185 feet above sea level. The land on the divide between Oconee and Ohoopee rivers is probably 200 feet higher.

GEOLOGY.

Sands, clays, and marls of the Claiborne group of the Eocene outcrop to the northwest in Washington County and underlie the entire area of Johnson County beneath the younger formations, with a probable aggregate thickness of 300 to 400 feet. The Claiborne group is overlain by the Jackson formation (Eocene), which consists of 100 feet

or less of limestone interbedded with sandy layers and which outcrops in a small area in the northwest. The Jackson formation is overlain by 100 feet or less of limestone belonging to the Vicksburg formation (Oligocene), which outcrops in a small area in the northwest and probably underlies the entire county. In the southern part of the county the Vicksburg formation is probably overlain by the sands and clays of the Alum Bluff formation (Oligocene), but these beds are not known to outcrop at the surface.

Overlapping the Oligocene and Eocene formations and constituting the surface formation throughout all but a small area in the extreme northwest are irregularly bedded sands and clays of undetermined age. Beneath the Claiborne group and not appearing at the surface are 500 to 800 feet of sands and clays of Cretaceous age, which at depths of 1,000 to 1,200 feet or more rest upon a basement of ancient crystalline rocks.

All the formations described doubtless contain water-bearing beds, but the Vicksburg formation, the Claiborne group, and the Cretaceous deposits are probably the most important aquifers.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The main sources of water supply are wells 20 to 40 feet deep, which yield soft waters. Small seepage springs are fairly common and there are a few bold limestone springs, but none are important as sources of domestic water supply. Deep wells have been drilled at Wrightsville, Idylwild, and Kite.

Artesian water can be obtained anywhere in the county at depths ranging from 100 to 1,000 feet or more. The prospects for obtaining flows on the lowlands bordering Oconee and Ohoopee rivers are good. Two flowing wells have been obtained at Idylwild on Ohoopee River, 3 miles below Wrightsville, but one of them flows only intermittently.

LOCAL SUPPLIES.

Wrightsville (population 1,389, census of 1910).—The town of Wrightsville owns a water-supply system and derives water from an artesian well (No. 5, Table 49) which was completed in 1911. The well is 409 feet deep, 8 inches in diameter, and yields 132 gallons of water a minute by pumping. Two water-bearing beds were struck, one at 170 feet and the other at 409 feet; the water from the first rises to within 45 feet of the surface, and that from the second, which is probably in the Claiborne group, to within 40 feet of the surface.

Slits were cut in the casing to admit water from the 170-foot stratum, so that the water used is a mixture from the two beds. An analysis of the mixed waters is given in Table 50 (analysis 2).

An abandoned well (No. 4, Table 49), formerly used by the town, located on the town square at a somewhat higher elevation than the new well, is 578 feet deep, and in it the water rises to within 62 feet of the surface. This well furnished only 30 gallons of water a minute, too little for the needs of the city. An analysis is given in Table 50 (analysis 3).

Idylwild.—Idylwild is a picnic resort on Ohoopee River, 3 miles south of Wrightsville. Two flowing wells have been obtained at this place, one 305 feet deep (No. 1, Table 49) and the other about 100 feet deep (No. 2, Table 49). The principal water-bearing bed is at a depth of 100 feet, and the water rises to a maximum height of about 2 feet above the surface. According to D. R. Thomas, however, the 305-foot well ceases to flow in October, the static head falling to 2 feet below the surface, and does not flow again until February or March. Mr. Thomas has furnished an analysis of the water, by J. M. McCandless. (See Table 50, analysis 1.)

Kite (population 241, census of 1910).—A well (No. 3, Table 49) at Kite, owned by the town, is reported to be 180 feet deep and to contain water that rises to within 165 feet of the surface. In wells sunk to greater depths in this part of the county the static head would probably be much nearer the surface.

TABLE 49.—*Wells in Johnson County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.
1	Idylwild, 3 miles south of Wrightsville.	.....	.....	D. R. Thomas.....	.....
2	.....do.....	.....	.....	.....do.....	.....
3	Kite, 60 yards northeast of post office.	Town.....	.....	Postmaster.....	.....
4	Wrightsville (near courthouse).	.....do.....	.....	S. W. McCallie[a].....	1890
5	Wrightsville, $\frac{1}{10}$ mile southeast of public square.	.....do.....	Hughes Specialty Well Drilling Co., Charleston, S. C.	Arthur Pew, consulting engineer Hughes Specialty Well Drilling Co.	1911

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute by pumping.	How obtained.	Quality.
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*		
1	305	.....	100	.....	+2 to −2	.....	.....	Analysis 1, Table 50.
2	100	.....	100	.....	+ 2	.....	Flows.....	
3	180	.....	180	165	−165	.....	.....	
4	578	4	430, 578	.....	− 62	30	.....	Analysis 3, Table 50
5	409	8	170, 409	.....	− 40	130	Air-lift pump.....	Analysis 2, Table 50.

[a] Georgia Geol. Survey Bull. 15, p. 131, 1908.

TABLE 49.—*Wells in Johnson County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Drinking	Vicksburg formation?		Ceases to flow in October and begins to flow again in February or March.
2	do	do		
3	Domestic, etc	Alum Bluff formation.		
4	Domestic	Claiborne group	Sand	Abandoned.
5	Municipal supply	do		8-inch casing to 400 feet. Slits in casing admit water from the 170-foot stratum. Cost of well, $1,800.

TABLE 50.—*Analyses of underground waters from Johnson County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1		Artesian well	Idylwild, 3 miles south of Wrightsville.	Vicksburg formation?	100	J. M. McCandless.
2	Apr. 30, 1911	Town well	Wrightsville	Claiborne group.	170, 409	Edgar Everhart.
3		Abandoned town well.	do	do	430, 578	H. C. White.[a]

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	35	[b]1.0	35	0.8	2.2	.....	87	0.6	.....	3.0	.....	.....	Total depth of well, 305 feet. Phosphate radicle (PO_4) =0.1. Well 1, Table 49.
2	25	4.0	58	2.0	5.0	0.0	207	Tr.	0.2	9.5	.....	226	Slits in casing admit water from the 170-foot stratum. Well 5, Table 49.
3	13	2.3	62	2.2	5.4	.0	190	15	.....	5.6	41	241	Free carbon dioxide is present. Well 4, Table 49.

[a] Georgia Geol. Survey Bull. 15, p. 131.

[b] $Fe_2O_3+Al_2O_3$.

JONES COUNTY.

GENERAL FEATURES.

Jones County is located in the central part of Georgia on the border between the Piedmont Plateau and the Atlantic Coastal Plain. Its area is 377 square miles and its population 13,103 (census of 1910). Agriculture is the chief industry.

TOPOGRAPHY.

The southeastern part of Jones County, less than one-fourth the total area, lies in the Coastal Plain, the other three-fourths being

included in the Piedmont Plateau. The Coastal Plain area forms a part of the physiographic division of the fall-line hills. The surface is hilly, having been much dissected by the headwater streams of Commissioners and Big Sandy creeks. The maximum relief is probably between 200 and 300 feet. The drainage is to Oconee River through its tributaries, Commissioners and Big Sandy creeks.

GEOLOGY.

Ancient crystalline rocks outcrop at the surface in the part of the county included within the Piedmont Plateau. Their upper surface slopes south and passes beneath the deposits of the Coastal Plain which form the surface materials in a relatively small area in the southeastern part of the county. These deposits are for the most part of Lower Cretaceous age and consist of coarse, irregularly bedded sands with subordinate clay lenses, the total thickness of which probably does not exceed 100 feet. Overlapping the Lower Cretaceous deposits are small areas of sands and clays belonging to the Claiborne group of the Eocene, which occupy some of the ridges between the small streams.

The Lower Cretaceous deposits are favorable in texture and composition to the absorption and circulation of waters, but the small thickness attained by these deposits within the county limits precludes the possibility of obtaining large quantities. However, sufficient amounts for domestic purposes are available at many places.

WATER RESOURCES.

The area underlain by Lower Cretaceous deposits is relatively small and the greatest thickness of the Cretaceous strata probably does not exceed 100 feet. Consequently wells in the southeast more than 100 feet deep pass entirely through these deposits and enter the underlying basement crystalline rocks. J. R. Van Buren & Co., of Griswoldville, own a dug well 84 feet deep a mile north of the town, which yields a small amount of soft water from the Lower Cretaceous sands for general domestic purposes. Wells of a similar character are in use in other parts of this area.

Mr. Van Buren has furnished a description of the materials penetrated in the well just described. The log is given below:

Log of well of J. R. Van Buren & Co., 1 mile north of Griswoldville.

	Thickness.	Depth.
	Feet.	*Feet.*
Sand, about	8	8
White clay	(?)	(?)
Red clay	(?)	(?)
Silica sand, water bearing	(?)	78
White clay	6	84

Small springs in the Cretaceous area yield waters of good quality. Numerous small creeks and headwater branches furnish excellent water for stock and for making steam.

As the Cretaceous strata in the southeastern part of the county probably do not exceed 100 feet in thickness, and as the topography of the region is such as to favor the rapid drainage of the beds, thus producing a low water table, only moderate supplies of water can be expected from this source. Little if any pressure is developed in the wells, and water from the Cretaceous beds in the area can scarcely be classed as artesian.

LAURENS COUNTY.

GENERAL FEATURES.

Laurens County is in the north-central part of the Coastal Plain of Georgia. Dublin, the county seat and commercial center, is 45 miles southeast of Macon. The area of the county is 806 square miles and the population is 35,501 (census of 1910). Agriculture is the principal industry, but the production of lumber and naval stores, though declining, is still important. Manufacturing plants at Dublin include cotton mills, fertilizer factories, cottonseed-oil mills, an ice factory, a furniture factory, and other small plants.

TOPOGRAPHY.

The county presents two fairly well marked types of topography. The northern part falls within the physiographic division known as the Dougherty plain and is characterized by a nearly level surface underlain by limestones and marked by lime sinks. It differs in soil, native vegetation, and topography from the part of the county south of Dublin and south of the Wrightsville & Tennille Railroad, where the surface exhibits low gently rounded sand hills, broad shallow valleys, and other features characteristic of the northern border of the Altamaha upland (long-leaf pine and wire-grass section).

Oconee River, which flows through the county, is bordered by narrow swamps and at higher levels by Pleistocene terraces, which in places are easily distinguishable. The city of Dublin is situated in part upon such a terrace. The Oconee is a so-called muddy-water stream while its tributaries in the county are small clear-water streams.

Determinations of altitude have been made on Oconee River and at the stations on the Macon, Dublin & Savannah Railroad. (See list of elevations, pp. 44–51.) The altitude of the low-water stage of Oconee River at Dublin is 160.6 feet above sea level and the upland both east and west of the river rises 100 to 150 feet above this level.

GEOLOGY.

The Jackson formation (Eocene), which consists of 150 feet or more of limestones, outcrops in the extreme north and probably underlies the remainder of the county beneath younger formations. Limestones of the Vicksburg formation (Oligocene) overlie the Jackson formation and outcrop over much of the county north of Dublin and in the valley of Oconee River to a point about 10 miles below Dublin; they extend southward beneath younger formations beyond the southern limits of the county. The Vicksburg formation weathers to red or gray sands containing in places masses of flint. Undifferentiated limestones, probably representing the Vicksburg and Jackson formations, were penetrated in a well at Rentz between 147 ? and 310.5 feet.

In the southern part of the county the Vicksburg formation is overlain by sands and clays of undetermined thickness belonging to the Alum Bluff formation. These outcrop only in the valley of Oconee River.

Overlapping the Alum Bluff and Vicksburg formations and extending north from the southern boundary of the county, apparently as an overlap across more than half the county, are irregularly bedded sands and clays of undetermined but probably upper Oligocene age. The thickness of these beds probably does not exceed 100 feet and in most places is probably much less than this amount, and the maximum combined thickness of the Vicksburg and Alum Bluff formations probably does not exceed 200 or 250 feet.

Terrace sands of Pleistocene age have been deposited in limited areas bordering Oconee River.

The Jackson formation is underlain by 400 or 500 feet of sands, clays, and marls belonging to the Claiborne group of the Eocene, but these beds do not appear at the surface within the county. The Claiborne in turn is underlain by perhaps 600 to 800 feet of sands and clays of Cretaceous age which rest upon a deeply buried surface of ancient crystalline rocks.

The Vicksburg and Jackson formations, the Claiborne group, and the Cretaceous deposits are believed to be important aquifers.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug wells 20 to 60 feet deep are the main sources of water supply, but a few artesian wells have been drilled.

The water of the shallow wells is soft, except in places in the northern part of the county where the wells penetrate calcareous layers in the Vicksburg or Jackson formations. The water of the artesian

wells thus far obtained is hard but is suitable for general domestic purposes.

Small springs are fairly common but are not used extensively. (See analyses 2, 3, and 4, Table 52.) Parker Spring is near Lovett, and Rinehart Keystone Mineral Spring, locally reputed to possess therapeutic properties, is near Dudley. In the limestone areas there are several large springs. (See p. 304.)

Artesian water can be obtained anywhere in the county at depths of 100 to 1,000 feet or more, and flowing wells are possible in the valleys at elevations not more than 70 feet above low-water level of Oconee River.

In the southern part of the county the limestones of the Vicksburg and Jackson formations are the most promising aquifers. Throughout the county the deeply buried Eocene and Cretaceous deposits are promising sources of artesian water.

LOCAL SUPPLIES.

Dublin (population 5,795, census of 1910).—According to McCallie [1] the municipal water supply of Dublin, the county seat, is obtained from several flowing artesian wells, 300 to 850 feet deep, on a terrace about 50 feet above low-water level of the river.

One water-bearing stratum was encountered at 185 feet, probably in the Vicksburg formation, and another at 295 feet in either the Jackson formation or the Claiborne group of the Eocene. The water from the 295-foot stratum rises 30 feet above the surface. In one of the city wells the principal water-bearing bed is 375 feet, according to Mayor E. S. Orr. The water is hard, but has proved satisfactory for general domestic purposes. (See analysis 1, Table 52.) Several flowing wells are owned by individuals.

Dexter (population 550, census of 1910).—The main sources of domestic water supply at Dexter are dug wells 20 to 60 feet deep, which tap the water-bearing gravels and sands beneath layers of clay. The town owns a water-supply system, used chiefly for fire protection. The water is derived from a drilled well and is reported to be hard.

Tingle.—At Tingle, a small station on the Wrightsville & Tennille Railroad 7 miles southwest of Dublin, a well owned by Jeptha Tingle is 242 feet deep and flows 20 feet above the surface. The water is derived from limestone, probably belonging to the Jackson formation. (See analysis 5, Table 52.)

Rentz (population 275, census of 1910).—A well 310.5 feet deep, owned by the Rentz Lumber Co., has been drilled at Rentz. A sample said to represent the materials between 147 and 310.5 feet (sample on file in the office of the United States Geological Survey,

[1] Georgia Geol. Survey Bull. 15, pp. 132–133, 1908.

well No. 770) is a white, porous, fossiliferous limestone in which were recognized fragments of echinoids, Bryozoa, and *Pecten perplanus* Morton? (identified by T. W. Vaughan). The Bryozoa were examined by R. S. Bassler, who regards them as related to the bryozoan fauna of Jackson age (Eocene) obtained from limestones at Wilmington, N. C., but states that they may indicate either a Jackson or a Vicksburg age for the material.

Limestone springs.—Well, Rock, and Wilkes springs, 9 to 14 miles south of Dublin, are the largest in the county. They are in the lowland on the west side of Oconee River at elevations not exceeding 15 feet above the level of the river and are therefore subject to overflow. The springs emerge from caverns in limestones and each probably yields more than a million gallons daily. Thundering Spring, about 12 miles northeast of Dublin, is a large limestone spring in which the level of the water continually rises and falls. An analysis of water from Lovett Spring, owned by L. P. Fordham, near Lovett, is given in Table 52 (analysis 3).

TABLE 51.—*Wells in Laurens County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Dublin	Sam Bashinski	N. T. Bastick	Mrs. N. T. Bastick		
2	do	Town	John Carter	E. S. Orr, mayor	1896	184
3	Rentz	Rentz Lumber Co	H. F. Loyd	Driller	1905	
4	Tingle (7 miles southwest of Dublin).	Jeptha Tingle, R. D. 3, Dublin.	M.D.Mikle, Arabi	D. R. Thomas and Jeptha Tingle.	1910	

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Height of water above surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	290								
2	375	4½, 2	375	200, 280		160		Flows	Hard.
3	310.5								
4	242	4½	242	220	20	20		Flows	Analysis 5, Table 52.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1		Jackson formation?		
2	Domestic	Claiborne group		Cost of well, $800.
3		Jackson formation?		
4	Domestic	do	Limestone	4½-inch casing to 104 feet.

TABLE 52.—*Analyses of underground waters from Laurens County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	.....	Well at municipal water-supply plant.	Dublin.....	Jackson formation?	185–295	Edgar Everhart.[a]
2	June 3, 1911	Rinehart Keystone Mineral Spring No. 4.	Dudley (near).....	.....	.....	Do.
3	July, 1909	Lovett Spring, owned by L. P. Fordham.	Lovett.....	Vicksburg formation?	.....	Do.
4	Sept., 1909	Parker Spring, owned by O. W. Parker.	Lovett, ½ mile southwest of.	Late Oligocene?.	.....	Do.
5	May 11, 1911	Well of Jeptha Tingle.	Tingle (7 miles southwest of Dublin).	Jackson formation?	220–242	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	20	[b]2.6	68	3.7	6.6	3.1	0.0	211	17	.....	5.6	.....	231	Free carbon dioxide (CO_2)=64.
2	2.0	.2	8.0	.5	3.0		.0	29	Tr.	0.4	4.0	.....	40	
3	17	.1	50	.2	5.0	.4	.....	144	2.6	.....	5.0	.....	158	
4	14	.2	1.5	.8	2.8	.1	.....	10	2.4	.....	4.4	.....	30	
5	32	1.5	58	3.0	8.0		.0	203	1.0	Tr.	5.0	.....	256	Well 4, Table 51.

[a] Georgia Geol. Survey Bull. 15, p. 132, 1908. [b] $Fe_2O_3+Al_2O_3$.

LEE COUNTY.

GENERAL FEATURES.

Lee County lies in the west-central part of the Coastal Plain of Georgia. Flint River forms the eastern boundary. Leesburg, the county seat, is 89 miles south of Macon and 24 miles north of Albany. The area of the county is 326 square miles and its population 11,679 (census of 1910). Agriculture and the production of lumber and naval stores are the principal industries.

TOPOGRAPHY.

Lee County is in general nearly level. Lime sinks are numerous and are commonly shallow. They vary in size from those having a diameter of 50 feet to those covering 100 acres or more. Many of them contain water during either a part or all of the year, and some support a growth of cypress trees. In some of the sinks, which appear to be connected with underground streams, the level of the water has been known to rise or fall suddenly. The surface of the county is estimated to lie between 200 and 335 feet above sea level.

GEOLOGY.

The Vicksburg formation (Oligocene), which appears at the surface throughout practically all the county, consists of 200 to 300 feet of impure, cavernous, water-bearing limestones, which weather at the surface to red sandy clays, or sands containing fragments and masses of flint. The thickness of the residual materials varies from place to place, but is usually great enough to supply shallow dug wells.

Small areas of thin Pleistocene terrace deposits border Flint River.

The Vicksburg formation is underlain by 200 to 300 feet of undifferentiated sediments of Eocene age, which contain important water-bearing beds. The Eocene deposits are in turn underlain by 1,500 feet or more of sands, clays, and marls of Cretaceous age, also important for their contained artesian waters. At an unknown depth, probably between 2,000 and 3,000 feet, the Cretaceous deposits rest upon a basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Water for domestic use is obtained chiefly from dug or bored wells 30 to 90 feet deep, and from many artesian wells 160 to 900 feet deep. The dug and bored wells tap water-bearing beds in the Vicksburg formation, and although they commonly afford an abundance of water, the yield in some of them has been known to decrease during dry seasons. Limestone springs are fairly common, but none of large size have been reported, and none are of much importance as sources of water supply.

The waters of creeks and ponds are suitable for stock and, being softer, are usually more satisfactory for boiler supply than the waters of artesian wells.

Artesian water can be obtained at depths of 100 to 1,500 feet or more, and it is probably possible, by deep drilling, to obtain flowing wells throughout the greater part of the county.

LOCAL SUPPLIES.

Leesburg (population 705, census of 1910).—There are three public and several private artesian wells at Leesburg. According to McCallie,[1] the earlier of the three public wells (No. 3, Table 53), drilled in 1893, is 540 feet deep and contains water that rises to within 12 feet of the surface. (See analysis 2, Table 54.) Another well is at the town light plant (No. 4, Table 53) and is about 300 feet deep; it does not flow. Its water is hard and differs somewhat in mineral character from that of the deeper well. (See analysis 3, Table 54.)

[1] Georgia Geol. Survey Bull. 15, pp. 133, 134, 1908.

Other deep wells at Leesburg, owned by individuals, range in depth from 160 to 750 feet; some are flowing wells and some nonflowing.

Additional information is given by McCallie[1] as follows:

W. M. Johnston's well, located on his plantation, 2½ miles west of Leesburg, has a depth of 150 feet and furnishes a flow 6 feet above the surface. Two water-bearing strata are reported, but only the second stratum furnishes a flow. The well is 3 inches in diameter and flows about 18 gallons per minute. The flow is said to be somewhat reduced in dry seasons.

The following record is furnished:

[*Log of W. M. Johnston's well, 2½ miles west of Leesburg (No. 7, Table 53).*]

	Feet.
Clay	0– 9
Limestone	9– 13
Cavity	13– 24
Marl	24–104
Limestone with flint	104–144
Sand (water bearing)	144–150

In addition to the well here described, Mr. Johnston also has three other wells on his plantation, varying from 100 to 384 feet in depth, but none of these wells furnish a flow. The water is used only for general farm purposes.

Smithville (population 574, census of 1910).—The public water supply at Smithville is obtained in part from three artesian wells, one about 900 feet deep and each of the other two 370 feet deep. The 900-foot well (No. 11, Table 53) flows, but the water is raised by a pump to a tank and thence distributed to the consumers. The water is clear, soft, and sulphurous, and is satisfactory for domestic use. In the 370-foot wells the water rises to within 25 feet of the surface. Two wells, each about 900 feet deep, owned by the Central of Georgia Railway Co. supply water used principally in the locomotive boilers. A description of one of the wells is given by McCallie[2] as follows:

One of the railroad wells, which is 3 inches in diameter, attains a depth of 900 feet. Two water-bearing strata are reported in this well—one at 500 and the other at 900 feet. Water rises 20 feet above the surface. It is used to supply the railroad water tank. The flow at the surface is about 50 gallons a minute.

Mr. G. W. Warwick, the well contractor, has furnished the following partial record:

[*Log of Central of Georgia Railway Co.'s well at Smithville (No. 12, Table 53).*]

	Feet.
Clay and sand to	40
Clay of various colors to	140
Cavernous rock (?) to	240
Blue clay with shells and sharks' teeth to	340
Limestone	345
Cavernous limestone with corals	(?)

At the bottom of the well the drill struck very hard rock that could not be penetrated.

[1] Georgia Geol. Survey Bull. 15, pp. 134, 135, 1908. [2] Idem, p. 135.

Armena.—Armena is a station on the Seaboard Air Line Railway in the southwestern corner of the county. The following description of deep wells at this place is given by McCallie:[1]

The deep wells at Armena, owned by Mr. I. P. Cocke, are three in number. They vary in depth from 290 to 450 feet. They are all nonflowing wells, and they were sunk chiefly to obtain water for plantation uses. The water rises to a varying height of from 24 to 68 feet of the surface.

Mr. Cocke gives the following record of one of his wells:

[*Log of I. P. Cocke's well at Armena (No. 2, Table 53).*]

	Feet.
Blue clay	0– 40
Limestone	40–190
Quicksand	190–250
Flint (?)	250–280
Cavity from which water rises to within 25 feet of the surface	280–290

Adams.—Adams is a small station on the Central of Georgia Railway between Smithville and Leesburg. The water supply here is obtained from dug and drilled wells ranging in depth from 30 to 180 feet. One well (No. 1, Table 53), owned by Mr. L. G. Council, is 180 feet deep; the water in it stands within 15 feet of the surface.

Philema.—Philema is a small station near Flint River on the Albany & Northern Railroad. In the vicinity of the town there are several artesian wells drilled for plantation use. A well (No. 9, Table 53) near the station is 124 feet deep and once flowed 15 feet above the surface, but now flows only 18 inches above it. The yield is affected by droughts and by periods of heavy rainfall. Limestone was struck at a depth of 40 feet. The water is said to be derived from a sand bed at the bottom.

A well (No. 10, Table 53) on the Brown plantation at Philema Quarters, one-half mile west of Philema station, is 142 feet deep. When the well was completed the water rose above the surface, but it now stands 15 feet below the surface. The elevation of the mouth of the well is a few feet above that of the other wells just described in this vicinity. (See analysis 4, Table 54.)

On the Starr farm (S. B. Brown plantation), a mile north of the station, there is a well (No. 8, Table 53) 114 feet deep which flows 6 feet above the surface. Casing extends to 40 feet, at which depth limestone is said to have been encountered. The well is on the second river terrace about 50 feet above low-water level of Flint River. (See analysis 5, Table 54.)

[1] Georgia Geol. Survey Bull. 15, pp. 136, 137, 1908.

TABLE 53.—*Wells in Lee County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Adams	L. G. Council, Americus.		C. W. Scarborough		
2	Armena	I. P. Cocke		S. W. McCallie[a]		275
3	Leesburg	Town		do	1893	300±
4	do	City light plant		C. H. Beazley		300±
5	do			Mayor		300±
6	do	Town	J. J. Cocke	E. B. Martin	1905	300?
7	Leesburg (2½ miles west of).	W. M. Johnston		S. W. McCallie[a]		300?
8	Philema (1 mile north of).	S. B. Brown		Otto Veatch		(b)
9	Philema (near station).			do		
10	Philema (½ mile west of).	S. B. Brown		do		
11	Smithville	Town	G. W. Warwick	G. W. Warwick and S. W. McCallie.[a]	1890	332
12	do	Central of Georgia Ry		S. W. McCallie[a]		332

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	180	6			−15			Hand pump	Hard.
2	290–450				−24–68				Hard; analysis 1, Table 54.
3	540	3			−12				Hard; analysis 2, Table 54.
4	300±	3						Force pump	Hard; analysis 3, Table 54.
5	750							Pump	
6	165	3	165	150	−20		5		Hard.
7	150	3	144–150		+ 6	18		Flows	
8	114				+ 6			do	Analysis 5, Table 54.
9	124				+ 1½			do	
10	142				−15				Analysis 4, Table 54.
11	900±	4		350–400	+18			Flows, but is pumped to tank.	Soft, sulphurous.
12	900	3	900	500	+20	50		Flows	

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Vicksburg formation.	Sand	Cost of well, $180; cost of pump, $15.
2	Farm use	Eocene?	Cavity in rock	3 wells. See log, p. 308.
3	Domestic	do		Cost of well, $1,200.
4		do		
5		Cretaceous		
6	Domestic, manufacturing.	Cretaceous?	Gravel	3-inch casing to 130 feet. Other wells reported 100 to 700 feet deep, some of which flow 12 feet above surface; cost of well, $165; cost of pump, $20.
7	Farm use	Vicksburg formation.	Sand	Three other nonflowing wells on farm 100 to 384 feet deep. See log, p. 307.
8		do		
9		do	Sand	
10		do		
11	Municipal supply	Cretaceous		Limestone from 330 to 470 feet; two other wells, each 370 feet deep, owned by the town, were drilled in 1904; water rises to within 25 feet of the surface.
12	Boiler supply of locomotives.	do		See log, p. 307. Railway owns another similar well.

[a] Georgia Geol. Survey Bull. 15, pp. 133, 137, 1908.
[b] Elevation about 50 feet above low-water level of Flint River.

TABLE 54.—*Analyses of underground waters from Lee County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	.....	Well of I. P. Cocke.	Armena.....	Eocene?.....	290+	Edgar Everhart.[a]
2	.....	Town well (drilled 1893).	Leesburg.....	.....do.....	540	Do.[a]
3	Mar., 1909	Well at city light plant.	.....do.....	.....do.....	300±	Edgar Everhart.
4	Mar. 30, 1911	S. B. Brown (Quarters well).	Philema.....	Vicksburg formation.	142	Do.
5	.....do.....	S. B. Brown (Starr farm well).	.....do.....	.....do.....	114	Do.

No.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Phosphate radicle (PO_4).	Total dissolved solids.	Remarks.
1	9.2	[b]2.1	.....	60	0.7	1.9	0.7	.....	183	5.9	.....	6.3	.....	174	Free carbon dioxide (CO_2)=22; well 2, Table 53.
2	35	[b]6.2	.....	26	3.4	27	5.0	.....	151	13	.....	5.2	.....	195	Well 3, Table 53.
3	18	.5	0.5	54	1.2	2.9	.3	.....	148	3.1	.....	3.0	.....	169	Well 4, Table 53.
4	13	12	.....	49	2.0	4.0		0.0	178	2.0	0.2	3.6	0.1	177	Well 10, Table 53.
5	12	1.5	.....	44	3.2	2.9		.0	166	4.8	2.5	3.0	.....	167	Well 8, Table 53.

[a] Georgia Geol. Survey Bull. 15, pp. 133, 134, 136, 1908.

[b] $Fe_2O_3+Al_2O_3$.

LIBERTY COUNTY.

GENERAL FEATURES.

Liberty County, the third largest county in the State, is on the coast in the eastern part of the Coastal Plain. Its area is 936 square miles and its population is 12,924 (census of 1910). The production and shipment of naval stores and lumber are the principal industries, but farming is carried on to an important extent in the north. A large roofing-tile factory at Ludowici is the only important manufacturing establishment.

TOPOGRAPHY.

The county is divisible into three physiographic parts: (1) A nearly level marine terrace plain (the Satilla), which extends 15 to 20 miles inland from the coast and lies 10 to 25 feet above sea level; (2) a sand-covered plain (the Okefenokee), which lies 60 to 100 feet above sea level and parallels the first plain, the two being separated by a low escarpment which is easily recognizable in the vicinity of Walthourville and Hinesville; and (3) a small area of level to slightly rolling land (the Altamaha upland), in the west near the Tattnall County line, which is, for the most part, more than 100 feet above sea

level and is better drained than the lower plains just described. The county is dotted with small cypress and gum swamps.

Altamaha River, which forms the southwestern boundary of the county, is bordered by a wide swamp limited on the east by a low sand ridge. East of the sand ridge there is an area of low, flat, clay land subject to overflow during very high water stages of the river. Bordering the coast are numerous islands separated from each other by a network of short tidewater creeks and rivers. Salt-water marshes and tidewater swamps cover considerable areas on the islands and on the adjacent mainland. The streams have shallow valleys and the creeks and branches flow sluggishly or spread out through swamps which border their courses. Geologically the whole land surface is of relatively recent origin and has been only slightly affected by stream erosion or other destructive processes.

GEOLOGY.

White or yellow sands and subordinate clays or silts, of Pleistocene age, cover the surface from the coast inland to a few miles west of the Atlantic Coast Line Railroad. Their maximum thickness is believed to be less than 50 feet, and over most of the area they are much thinner. They are the source of some of the waters obtained in shallow dug and driven wells. Throughout the remainder of the county in the west, irregularly bedded sands and clays of undetermined geologic age, whose aggregate thickness probably does not exceed 50 or 75 feet, appear at the surface and supply waters to shallow dug or driven wells.

A series of undifferentiated Tertiary deposits underlies the surficial deposits. In their upper 400 or 450 feet these deposits consist of sands, greenish or drab sandy clays, with subordinate layers of limestone, phosphatic sand, or sandy shell marl and gravel, and probably include representatives of the Pliocene, the Miocene, and the Alum Bluff formation of the Oligocene. Below them lies 800 to 900 feet or more of soft limestones interbedded with layers of sand and shell marl, probably representing the Chattahoochee and Vicksburg formations of the Oligocene and the Jackson formation of the Eocene. The limestones are followed by sands which extend to a depth of about 1,900 feet (see section of well at Doctortown, Wayne County, p. 453), below which nothing definite is known concerning the deposits. It is believed, however, that the Tertiary deposits are underlain by a considerable thickness of sediments of Cretaceous age, and that at some unknown depth, perhaps 3,000 feet or more, the Cretaceous deposits rest upon a basement of ancient crystalline rocks. The Tertiary deposits and probably also the Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Throughout the county dug or driven wells, 10 to 30 feet deep, are the main source of domestic water supply. Artesian wells have been drilled at or near Ludowici, Donald, Allenhurst, Flemington, Riceboro, Dorchester, Arcadia, and on St. Catherines Island. There are a few small seepage springs in the northern part of the county. An analysis of water from one such spring, owned by T. J. Harrington, near Donald, is given in Table 56 (analysis 3).

Artesian water can be obtained anywhere at depths of 100 to 1,000 feet or more. Flowing wells are believed to be possible at all places less than 75 feet above sea level.

LOCAL SUPPLIES.

Ludowici (population 541, census of 1910).—Driven wells 20 to 30 feet deep are the principal source of water for domestic use at Ludowici, but there are also three artesian wells, one owned by the town and two by individuals. The public well (No. 8, Table 55), drilled in 1907, is near the Atlantic Coast Line Railroad station 71 feet above sea level. The well is 589 feet deep and the principal water-bearing bed is said to be a shell marl at the bottom. Originally the water rose to the surface, and in order to obtain a natural flow a shallow basin was excavated about the casing; however, in 1909 the static head had decreased to 5 feet below the surface and the flow ceased. The water emits a distinct odor of hydrogen sulphide and its content of iron is rather high; it is, however, suitable for general domestic purposes. An analysis is given in Table 56 (analysis 2). The following is a partial log:

Partial log of town well at Ludowici (No. 8, Table 55).

	Thickness.	Depth.
	Feet.	*Feet.*
Red sand	40	40
Blue clay	60	100
Gray sand	5	105
Sandstone	1	106
Sand	2	108
Blue clay	1	109
Blue rock	2	111
Sand	39	150
Blue clay	15	165
Sand (shells and teeth at 260 feet)	95	260
Blue and white clay	40	300
Gray sand	10	310
Greenish clay and sand	30	340
Not reported	(?)	(?)
Marl	(?)	(?)
		589

An artesian well (No. 9, Table 55) at the roofing-tile factory of the Ludowici-Celadon Co. is 607 feet deep. The water from the principal

water-bearing bed rises to within 7 feet of the surface. The mouth of the well is about 3 feet higher than that of the public well, but probably draws from the same water-bearing beds. A water-bearing shell marl was found at 300 feet, from which the water rose to within 25 feet of the surface. A fossil Pecten resembling *P. sayanus* was obtained from the 300-foot stratum, which suggests that the bed belongs to the Alum Bluff formation.

Donald.—Two deep wells (Nos. 3 and 4, Table 55) have been drilled near Donald, a small town on the Georgia Coast & Piedmont Railroad, 10 miles northwest of Ludowici. W. J. Floyd, the well contractor, has furnished the following logs and other detailed information concerning these wells:

Log of well of S. H. Howard, 3 miles southeast of Donald (No. 3, Table 55).

	Thickness.	Depth.
	Feet.	*Feet.*
Soil	2	2
Hard red clay	10	12
Sandy clay	5	17
Sand	14	31
Clay	37	68
Sand	2	70
Chalky clay	31	101
Hard blue pipe clay	6	107
Sand and coarse gravel	35	142
Dark marl	12	154
Salmon-colored clay	6	160
Fine sand	24	184
Coarse sand	14	198
Soft rock	23	221
Hard flint	3	224
Hard pipe clay	22	246
Hard marl	36	282
Fine sand	24	306
Hard marl	10	316
Soft rock	18	334
Coarse sand, water bearing	21	355
Hard rock	14	369
Soft porous rock, water bearing	25	394
Hard fine rock like soapstone	8	402

Log of well of T. J. Harrington, 1 mile south of Donald (No. 4, Table 55).

[Elevation of curb 12 feet below Georgia Coast & Piedmont R. R. track at Donald.]

	Thickness.	Depth.
	Feet.	*Feet.*
Alternating layers of clay, sand, and gravel	400	400
Hard rock	9	409
Clay (streaked)	5	414
Sand with thin layers of rock	13	427
Hard sandstone	7	434
Hard grayish stone	13	447
Hard whitish flint	4	451
Soft rock	4	455
Hard rock	19	474
Soft rock	9	483
Hard rock	3	486
Soft rock	25	511
Soft marl	16	527
Soft rock	23	550
Porous rock, water bearing	8	558
Marl and layers of hard whitish rock	60	618
Hard rock	22	640
Rock with large pockets containing water	20	660

Allenhurst.—A well (No. 1, Table 55) owned by the Byers-Allen Lumber Co. at Allenhurst, 12 miles east of Ludowici, completed in 1909, is 546 feet deep and 10 inches in diameter. It flows 800 gallons a minute 8 feet above the surface. The water is sulphurous and is used for domestic purposes and for boiler supply at a large lumber mill. A log of the well has been furnished by the Hughes Specialty Well Drilling Co., of Charleston, S. C.

Log of well of Byers-Allen Lumber Co., Allenhurst (No. 1, Table 55).

	Thickness.	Depth.
	Feet.	*Feet.*
Clay	20	20
Clay and sand layers	20	40
Fine sand	10	50
Coarse sand and gravel (water)	20	70
Fine sand and marl[a] layers	30	100
Blue marl[a]	30	130
Marl and sand	20	150
Coarse sand	20	170
Alternating marl and sand	130	300
Marl and rock	40	340
Rock, medium hard, small flow	20	360
Marl and sand	40	400
Rock and marl	20	420
Marl and sand	20	440
Limestone, flow increased	40	480
Shell formation; flows 800 gallons a minute from depth of 500 feet	20	500
Not reported	46	546

[a] All the strata called "marl" are probably clay.

Flemington.—There are several flowing wells near Flemington. A well (No. 7, Table 55) owned by A. G. Caison, a mile east of the post office, is 181 feet deep and flows a small stream 6 feet above the surface. A sample of water was analyzed for comparison with the water of the deeper well at Ludowici. (See Table 56, analysis 1.)

St. Catherines Island.—Six artesian wells on St. Catherines Island, five of which flow, are used for general domestic and plantation purposes. The wells are less than 500 feet in depth and furnish strong flows. Their static head is said to be slightly affected by the tides.[1]

W. J. Floyd, the driller, has furnished information regarding a well (No. 12, Table 55) drilled in 1909, at the south end of the island, 6 feet above sea level. This well is 438 feet deep, is cased to 230 feet, and flows 60 gallons a minute. Its static head is 42 feet above the surface.

Log of well on St. Catherines Island (No. 12, Table 55).

	Thickness.	Depth.
	Feet.	*Feet.*
Sand	38	38
Coarse sand and gravel with shells	3	41
Sand	189	230
Greenish marl	80	310
Grayish marl	75	385
Marl and layers of soft rock with first flow at 398 feet	13	398
Marl and layers of rock; flow at 432 feet	40	438

[1] Georgia Geol. Survey Bull. 15, p. 139, 1908.

Other localities.—Flowing wells are the chief source of water supply at Riceboro, Dorchester, and Arcadia. At each place the wells are less than 500 feet deep and yield strong flows of moderately hard water emitting an unpleasant odor of hydrogen sulphide. (See Table 55.)

TABLE 55.—*Wells in Liberty County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Allenhurst	Byers-Allen Lumber Co.	Hughes Specialty Well Drilling Co., Charleston, S. C., J. R. Connelly, driller in charge.	Hughes Specialty Well Drilling Co., Charleston, S. C.	1909	+10
2	Arcadia	Town				
3	Donald, 3 miles southeast of.	S. H. Howard	W. J. Floyd, R. F. D. 2, Savannah.	Driller	1913	
4	Donald, 1 mile south of.	T. J. Harrington	do	do	1912	
5	Dorchester	W. P. Wait		S. W. McCallie [a]		
6	Dorchester, 2 miles west of.	do		do		
7	Flemington	A. G. Caison	F. L. Perry			
8	Ludowici	Town	J. W. Wiggins	J. W. Wiggins and R. L. Horne.	1907	+71
9	do	Ludowici - Celadon Co.				+74
10	Riceboro	Seaboard Air Line Ry.		S. W. McCallie [a]		
11	Riceboro, 1 mile northeast of.	A. E. Winn		do		
12	St. Catherines Island.	J. Raner	W. J. Floyd	W. J. Floyd	1909	+ 6

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	546	10		150	+ 8	800		Flows	
2	225		223		+20	50		do	
3	402	2½	369–394	334–355	−14		20	Suction pump and gasoline engine.	Hard and sulphurous.
4	660	4	640–660	550–558	−11		120	do	Hard.
5	470	3				100		Flows	
6	450	6			+30	1,200		do	
7	181		181		+ 6	2		do	Sulphurous; analysis 1, Table 56.
8	589	8	589?		− 5				Analysis 2, Table 56.
9	607		592?	300	− 7				
10	460?		450?	350				Flows	
11	430?	2½	350?	350				do	
12	438	3	398–438		+42	60		do	Hard.

[a] Georgia Geol. Survey Bull. 15, pp. 137–139, 1908.

TABLE 55.—*Wells in Liberty County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Manufacturing, domestic.	Tertiary	Limestone and shell marl.	See log, p. 314.
2		do		
3	Domestic	do	Porous rock	6-inch casing to 165 feet; 4-inch casing to 243 feet; 2½-inch casing to 363 feet. Cost of well, $900; of machinery, $325. See log, p. 313.
4	do	do	Soft porous rock	8-inch casing to 200 feet; 6-inch casing to 409 feet; 4-inch casing to 550 feet. Cost of well, $1,600; of machinery, $275. See log, p. 313.
5		do		
6		do		
7	Domestic	do		3-inch casing to 72 feet.
8		do	Shell marl	See log, p. 312.
9		do		
10		do		
11		do		
12	Domestic	do	Marl and layers of rock.	3-inch casing to 230 feet. Cost of well, $450.

TABLE 56.—*Analyses of underground waters from Liberty County.*

[Parts per million.]

	1	2	3
Silica (SiO_2)	45	28	8.5
Iron (Fe)	.2	6.0	3.5
Aluminum (Al)			.2
Calcium (Ca)	16	28	2.0
Magnesium (Mg)	4.0	14	1.6
Sodium (Na)	54	20	4.7
Potassium (K)			.4
Carbonate radicle (CO_3)	1.2	2.0	
Bicarbonate radicle (HCO_3)	202	195	114
Sulphate radicle (SO_4)	7.0	7.0	.9
Nitrate radicle (NO_3)	.0	Trace.	
Chlorine (Cl)	5.0	3.5	8.7
Total dissolved solids	236	240	41

1. Well No. 7, Table 55. Sample collected May 5, 1911. Edgar Everhart, analyst.
2. Well No. 8, Table 55. Sample collected Apr. 8, 1911. Edgar Everhart, analyst.
3. Spring of T. J. Harrington, near Donald (10 miles northwest of Ludowici). Water from undifferentiated surficial deposits. Edgar Everhart, analyst.

LOWNDES COUNTY.

GENERAL FEATURES.

Lowndes County is in the south-central part of the Coastal Plain of Georgia and is one of the tier of counties bordering Florida. Its area is 482 square miles and its population 24,436 (census of 1910). The shipment of lumber and naval stores are important industries. Cotton goods, fertilizers, and other products are manufactured at Valdosta. Sea-island cotton is the most important agricultural product.

TOPOGRAPHY.

The northern part of the county is, in general, a nearly level plain, on which are numerous cypress ponds. In the south the surface is nearly level to slightly undulating. Lime sinks are numerous, some

of them being dry and others holding ponds and lakes, the waters of which are clearer than the waters of the streams. Ocean Pond, one of the largest of the few lakes of the State, has an area of 5 to 6 square miles. The county is bounded on the west by Withlacoochee River and is partly bounded on the east by Alapaha River. These streams have cut their beds 75 to 100 feet below the upland plain on which Valdosta is located, and are bordered by two low, sand-covered terrace plains, the lower of which lies 10 to 15 feet and the upper 30 to 40 feet above low-water level.

The known altitudes above sea level are Valdosta 218, Naylor 195, and Ousley 151 feet on the Atlantic Coast Line Railroad; Dasher 185, Lake Park 167, Melrose 154, State Line 161, Mineola 220, and Hahira 236 feet on the Georgia Southern & Florida Railway; Withlacoochee River water level 124, bridge level 140 feet.

GEOLOGY.

The Chattahoochee formation (Oligocene), which consists of 150 feet or more of porous, cavernous, water-bearing limestones, outcrops on Withlacoochee River, in the southern part of the county, and underlies the entire county beneath younger formations. The Chattahoochee formation is overlain by 50 to 150 feet of greenish sands and sandy clays belonging to the Alum Bluff formation (Oligocene), which outcrops in the southern part of the county and in the valleys of Withlacoochee and Alapaha rivers and their tributaries, and which locally contains water-bearing beds. Over the greater part of the county north of the latitude of Lake Park the Alum Bluff formation is overlain by 75 feet or less of irregularly bedded sands and clays of undetermined but possibly upper Oligocene age. Terrace sands of Pleistocene age have been deposited in narrow areas bordering Withlacoochee and Alapaha rivers.

The limestones of the Chattahoochee formation are believed to be underlain by similar water-bearing limestones referable to the Vicksburg formation (Oligocene), but the two formations have not been accurately discriminated in the county. However, fossils of Vicksburg age have been obtained in wells at Valdosta between the depths 400 and 480 feet. (See p. 319.)

Beneath the Vicksburg formation in descending order is a series of undifferentiated sediments of Eocene and Cretaceous age, which at an unknown depth, perhaps 3,000 feet or more, are believed to rest upon a basement of ancient crystalline rocks. These sediments contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Shallow dug, driven, and bored wells 15 to 75 feet deep are the chief source of domestic water supply in the county. All except a few

wells near the Florida line which penetrate limestones yield soft waters. Where only a small amount of water for domestic use is required wells of the driven type are preferable to wells of the other types, for they afford less opportunity for contamination from surface sources. Artesian wells have been drilled at and near Valdosta.

There are a few small springs in the county. The waters of the streams, ponds, and lakes are suitable for stock and for boiler supplies.

Artesian water can be obtained anywhere in the county at depths of 100 to 1,000 feet or more. Wells 500 feet or more in depth on the terrace plains bordering Withlacoochee and Alapaha rivers will probably flow.

LOCAL SUPPLIES.

Valdosta (population 7,656, census of 1910).—Valdosta owns a public water-supply system which obtains water from an artesian well (No. 1, Table 57), completed in 1900, 500 feet deep and 8 inches in diameter. The water, which rises to within 120 feet of the surface, is pumped at the rate of about 300,000 gallons daily. It is hard but has proved satisfactory for general domestic purposes. (See analysis 1, Table 58.)

McCallie [1] has published the following log:

Log of town well, Valdosta (No. 1, Table 57).

	Thickness.	Depth.
	Feet.	*Feet.*
Surficial sand	2	2
Yellow sand	20	22
Sand and gravel	50	72
Blue marl	8	80
Soft coral rock	37	117
Sandy clay, often indurated and phosphatic	59	176
Rather compact, brownish-gray limestone containing minute grains of transparent quartz sand	32	208
White porous limestone, water bearing	52	260
Same as above, with fragments of sea urchins	100	360
White porous limestone, water bearing	140	500

The limestones in the upper part of the well probably belong to the Chattahoochee formation and those in the lower part to the Vicksburg formation.

McCallie [2] describes a well (No. 2, Table 57) drilled by the town in 1893. Analyses of waters from different levels are given in Table 58 (analyses 2, 3, and 4).

From a set of well borings on file in the office of the United States Geological Survey (well No. 915), probably obtained from the town well drilled in 1893, the following partial log has been prepared. The Foraminifera were determined by J. A. Cushman.

[1] Georgia Geol. Survey Bull. 15, pp. 140, 141, 1908. [2] Idem, p. 140.

Partial log of well at Valdosta (No. 2, Table 57).

[Drilled by J. A. Durst; samples furnished by L. C. Johnson.]

	Feet.
Light-gray argillaceous sand and chunks of white clay at	48
Fragments of brown flint at	87
Chunks of chocolate-colored sandy silicified clay, white sandstone, and numerous fairly well rounded quartz pebbles up to one-half inch in longest dimension	88–90
Fragments of white sandy limestone and gray flint	117–122
Chunks of white silicified clay or claystone—some showing dendritic growths—and fragments of flint	123–125
Fragments of white limestone	130–132
Fragments of white sandy limestone, white silicified calcareous clay, and one fragment of flint	133–139
Fragment of white calcareous, sandy claystone at	153
Fragments of white sandy calcareous clay and rounded chunks of gray limestone	212–214
Small fragments of white limestone and gray flint	240–241
Large fragments of dark-gray flint and white limestone	247–250
Fragments of white sandy limestone, echinoid tests and spines, etc	311–350
Fragments of white fossiliferous limestone and flint; small flat echinoids, fragments of pelecypods, gastropods, etc	360–416
White limestone, containing numerous small Nummulites, Dispansus sp., a few small echinoids, etc	400–416
Same as preceding, containing Nummulites and Orbitoides	430–450
Same as preceding, containing Nummulites and Orbitoides, one fairly large *Orbitoides* cf. *O. ephippium* (Schloth), at	459
Fragments of brown magnesian [1] limestone	476–477
Fragments of white limestone, brown magnesian limestone, small echinoids, Nummulites, Orbitoides (2 species), and fragments of pelecypods and gastropods, at	477½
Same as preceding, containing Nummulites and Orbitoides at	480
Fragments of brown magnesian limestone	487–491
Same at	493
Same	502–522

According to T. W. Vaughan, a few fragments of fossils taken between 400 and 480 feet include Nummulites and indicate the Vicksburg age of that part of the section. Probably 280 to 300 feet of the section, up to and including the white limestone at 240 to 241 feet, should be referred to this formation.

At and near Valdosta many wells owned by individuals range in depth from 80 to 550 feet. Large quantities of water are obtained from porous and cavernous limestones.

A well (No. 3, Table 57) owned by J. B. Jones, completed in 1909, on the upland 2 miles northwest of Valdosta about 100 feet above Withlacoochee River is 226 feet deep. The water stands within 38 feet of the surface. The static head indicates that flows can be obtained at lower elevations in the valley to the west.

[1] The magnesian character of this limestone was determined by W. F. Hunt of the U. S. Geol. Survey.

TABLE 57.—*Wells in Lowndes County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Valdosta	Town		Hughes Specialty Well Drilling Co. and S. W. McCallie.[a]	1900	215
2	do	do	J. A. Durst	do	1893	215
3	Valdosta (2 miles northwest of).	J. B. Jones	L. C. Solomon	J. B. Jones	1909	(b)

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute on pumping.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	500	8	360–500	260	120	.....	200	.....	Analysis 1, Table 58.
2	522	4½	515	460	113	.....	.....	.....	Analyses 2, 3, and 4, Table 58.
3	226	2	225	125	38	.....	12	Gasoline engine	Hard.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Drinking and domestic.	Vicksburg formation?	Porous limestone	See log, p. 318.
2	Domestic	do	do	Cost of well, $1,600. See log, p. 319.
3	Domestic and boiler supply.	Chattahoochee formation?	Cavity in rock	3-inch casing, 103 feet; diameter below casing is 2 inches. Cost of well and machinery, $509.

[a] Georgia Geol. Survey Bull. 15, pp. 139–141, 1908.
[b] Elevation about 100 feet above the bed of Withlacoochee River.

TABLE 58.—*Analyses of underground waters from Lowndes County.*

[Parts per million.]

No.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
				Feet.	
1	Town well	Valdosta	Vicksburg formation?	360–500	Edgar Everhart.[a]
2	Old town well	do	do	360	H. C. White.[a]
3	do	do	do	460	Do.[a]
4	do	do	do	515	Do.[a]

No.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	15	[b]6.1	.....	25	3.1	2.8	1.1	0.0	61	24	5.4	.....	113	Free carbon dioxide (CO_2)=27; well 1, Table 57.
2	6.7	1.2	0.6	42	.6	3.5	.4	56	.....	13	4.9	20	150	Waters from 3 different levels in the town well drilled in 1893; well 2, Table 57.
3	8.0	1.1	.5	35	.7	3.1	.5	48	.....	12	4.2	23	138	
4	12	1.4	.9	41	.7	2.3	.3	56	.....	14	2.9	16	149	

[a] Georgia Geol. Survey Bull. 15, pp. 140, 141, 1908.
[b] $Fe_2O_3+Al_2O_3$.

McDUFFIE COUNTY.

GENERAL FEATURES.

McDuffie County is in the northeastern part of the State of Georgia on the border between the Piedmont Plateau and the Atlantic Coastal Plain. Its area is 287 square miles and its population 10,325 (census of 1910). Agriculture is the chief industry.

TOPOGRAPHY.

The county from a few miles north of the Georgia Railroad southward is included within the Atlantic Coastal Plain; the remainder lies within the Piedmont Plateau. The coastal plain area forms a part of the northern border of the physiographic division known as the fall-line hills and has been greatly dissected by the headwater streams of Brier Creek and is therefore very hilly. The maximum surface relief is probably between 200 and 300 feet.

GEOLOGY.

Crystalline rocks outcrop over the northern part of the county (Piedmont Plateau) and dip southward beneath deposits of the Coastal Plain. The Coastal Plain area extends to the southern limit of the county.

The deposits of the Coastal Plain consist of irregularly bedded arkosic sands and clays of Lower Cretaceous age which rest upon the eroded surface of the southward-dipping basement crystalline rocks. These dip unconformably beneath sands and clays referable to the Claiborne group of the Eocene, which cap the divides between Reedy, Brier, Headstall, and Boggy Gut creeks. The Lower Cretaceous deposits probably attain a maximum thickness of 200 or 300 feet in the southern part of the county. The Eocene deposits are relatively thin, perhaps not exceeding 50 or 75 feet. (See Pl. III, p. 52.)

WATER RESOURCES.

In the Coastal Plain area water for domestic use is derived from dug wells 15 to 90 feet deep which tap water-bearing beds, chiefly in the Lower Cretaceous deposits, and from small springs. The waters thus obtained are of good quality, though generally scanty. The wells, like others of shallow or of moderate depth in all regions, should be protected from surface contamination.

A deep well owned by the town of Thompson, the county seat, passes through about 73 feet of deposits of the Coastal Plain and penetrates the underlying crystalline basement rocks to a depth of 506 feet. Water which rises to within 10 feet of the surface is obtained from fissures or crevices in granite at depths of 125, 327,

and 450 feet. The daily yield of the well is said to be 12,000 gallons, which is used chiefly for drinking. McCallie [1] gives the following log:

Log of town well at Thompson.

	Thickness.	Depth.
Lower Cretaceous:	*Feet.*	*Feet.*
Bluish clay	23	23
Yellowish clay	50	73
Pre-Cambrian:		
Decomposed granite	10	83
Granite with occasional fissures	423	506

The following is an analysis of a sample of water from the Thompson well, Edgar Everhart, analyst:[2]

Analysis of water from town well at Thompson.

	Parts per million.
Silica (SiO_2)	32
Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$)	1.6
Calcium (Ca)	19
Magnesium (Mg)	2.1
Sodium (Na)	18
Potassium (K)	3.8
Carbonate radicle (CO_3)	55
Sulphate radicle (SO_4)	4.9
Chlorine (Cl)	3.3
Nitrate radicle (NO_3)	.0
Total dissolved solids	139

The Lower Cretaceous deposits probably attain a thickness of 200 or 300 feet in the extreme southern part of the county, where they are fairly promising as a source of artesian supply. They not only contain beds of porous sand, the texture and structure of which favor the retention of considerable quantities of water, but some artesian pressure is doubtless developed. However, it is probable that flowing wells can not be obtained.

As shown by the deep well at Thompson, fairly good supplies of potable water can be obtained from crevices in the crystalline basement rocks which underlie the deposits of the Coastal Plain.

McINTOSH COUNTY.

GENERAL FEATURES.

McIntosh County is in the southeastern part of the Coastal Plain of Georgia and borders the Atlantic coast. Its area is 470 square miles and its population is 6,442 (census of 1910). The shipment of lumber and naval stores, fishing, the canning of oysters, and agriculture are the principal industries.

[1] Georgia Geol. Survey Bull. 15, pp. 211, 212, 1908. [2] Idem, p. 212.

TOPOGRAPHY.

The greater part of the county is a nearly level plain which does not exceed 20 or 30 feet above sea level. Bordering the coast are numerous low sand-covered islands separated by a network of sounds, small tidal creeks, and salt marshes. Altamaha River, which forms the southern boundary, is bordered by a swamp a mile or two wide, limited on the north by a low ridge of dry sandy land overgrown with live oaks, behind which is a poorly drained pine flat with numerous small cypress and gum ponds and swamps, subject in part to overflow during high-water stages of Altamaha River. The ridge, which roughly parallels the river and the eastern margin of the mainland, is crossed by the Seaboard Air Line Railway near Barrington. Darien is located upon it. In the extreme north the land rises rather abruptly to 50 or 60 feet above sea level. Geologically the surface is youthful, having been only slightly affected by stream erosion.

GEOLOGY.

Terrace sands and clays of Pleistocene age, probably not exceeding 50 feet in thickness and in most places much thinner, appear at the surface throughout the county. Beneath these surficial deposits is a series of sands, clays, marls, and limestones probably having an aggregate thickness of several thousand feet, which in descending order are believed to be of Pliocene, Miocene, Oligocene, Eocene, and Cretaceous age. They contain numerous and important water-bearing beds. At an unknown depth, perhaps 3,000 feet or more, the Cretaceous deposits—the oldest of the sediments of the Coastal Plain—are believed to rest upon a basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Driven wells 10 to 25 feet deep are common and, as the water table is only a few feet beneath the surface, furnish abundant water. Dug wells are less general. In many of them the water stands so near the surface in rainy weather that it can be dipped by hand. The water from this shallow source is soft but not always wholesome, and in places tastes strongly of iron and organic matter.

Springs are few in number and of slight importance. Pond water is used to some extent for stock.

Twenty-five or more flowing artesian wells in the eastern part of the county and on the islands range in depth from 128 to 527 feet. Their waters are moderately hard and emit a strong odor of sulphur, but are clear and potable.

Artesian water can be obtained in great abundance anywhere at depths of 100 to 1,000 feet or more. The static head will almost everywhere be high enough to produce flows.

LOCAL SUPPLIES.

Darien (population 1,391, census of 1910).—Darien owns three artesian wells (Nos. 4, 5, and 6, Table 59). McCallie[1] has given the following information concerning two of them:

The first attempt to obtain artesian water at Darien was made in 1885 by sinking a 4-inch well to the depth of 492 feet. This well supplied the town with water until 1891, when the large 8-inch well now in use was completed. The 8-inch well is 530 feet deep. It flows about 200 gallons per minute. The water is hard and sulphureted, but quite wholesome. It rises 15 feet above the surface. The main water-bearing stratum is said to be near the bottom of the wells. Other strata are reported nearer the surface, though the flow is unsatisfactory.

A sample from the 530-foot well at the municipal waterworks plant, collected May 6, 1911, was analyzed by Edgar Everhart as follows:

Analysis of water from 530-foot well at the municipal water-supply plant, Darien.

	Parts per million.
Silica (SiO_2)	29
Iron (Fe)	6.0
Calcium (Ca)	34
Magnesium (Mg)	5.0
Sodium and potassium (Na+K)	46
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	156
Sulphate radicle (SO_4)	91
Nitrate radicle (NO_3)	.0
Chlorine (Cl)	12
Total dissolved solids	326

From a series of well borings McCallie prepared the following partial log of the 530-foot well:

Partial log of town well at Darien (No. 4, Table 59).

	Feet.
Very coarse sand and pebbles. Many of the pebbles, which consist of both quartz and feldspar, are only slightly rounded and are incrusted with a yellowish ocherous deposit at	125
Dark-gray marl having a greenish tint and containing numerous microscopic rhombohedral crystals of calcite	133(?)
Very fine gray sand with considerable clay; also a few large well-rounded quartz grains at	143
Fine brown sandy clay and fragments of shells at	167
Coarse sand, pebbles, and fragments of shells at	176

[1] Georgia Geol. Survey Bull. 15, pp. 147–150, 1908.

	Feet.
The same as the above except that it contains glauconite at	188
Gray marl made up largely of minute crystals of calcite with a few grains of coarse sand at	220
Fine gray micaceous sand and a few fragments of shells	221
Diatomaceous earth, greenish-gray, at	258
Diatomaceous earth with a few small crystals of selenite	280
Diatomaceous earth in which spicules of sponges are common at	330
Diatomaceous earth and a few particles of glauconite at	350
Diatomaceous earth at	375
Coarse sand and pebbles forming conglomerate, which contains sharks' teeth, small dental plates (possibly of the ray), fragments of shells, and pieces of lignite, many of which are an inch in diameter, at	385
Rather fine gray sand, with sharks' teeth, glauconite, a few diatoms and fragments of bone and shells, at	388
Indurated, highly calcareous light-gray marl resembling chalk at	391
Fine dark-gray sand containing small flakes of mica, diatoms, spicules of sponges and glauconite at	400
Fine yellow sand with fragments of shells, glauconite, and diatoms at	420
Hard, compact greenish clay, breaking with conchoidal fracture, at	440
Same at	500
Fine dark-gray glauconitic sand at	515
Same with fragments of shells at	524
Hard, compact claystone and sand	530

Valona.—Valona is a small village on the Georgia Coast & Piedmont Railroad 3 miles northeast of Meridian. A flowing well (No. 20, Table 59), owned by George E. Atwood (one of five flowing wells owned by him within 5 miles of Valona), is 455 feet deep and 3 inches in diameter. Mr. Atwood gives the following approximate log and states that those of the other four wells were generally similar:

Approximate log of well of George E. Atwood, Valona (No. 20, Table 59).

[Given from memory.]

	Thickness.	Depth.
	Feet.	*Feet.*
Sand or soft marl	100	100
Coarse gravel	30	130
Hard marl	190	320
Hard rock (limestone?); yields water which overflows at the surface	6	326
Marl with interbedded layers of rock 1 to 2 feet thick; contains water-bearing beds which yield flows	129	455

Sapelo light station.—A well owned by the United States Government at Sapelo light station (No. 19, Table 59), near the south end of Sapelo Island, completed in 1906, is 480 feet deep. From a set of well borings on file in the office of the United States Geological Survey (well

No. 625), furnished by Fred Baumgartner, the driller, the following log has been prepared:

Log of Government well at Sapelo light station, Sapelo Island (No. 19, Table 59).

	Thickness.	Depth.
	Feet.	*Feet.*
Fine loose sand at		20
Coarse clear sand	60	80
Medium-grained clear sand	5	85
Missing	5	90
Coarse sand with numerous fragments of shells	10	100
Medium to coarse sand with a few fragments of shells	23	123
Greenish-gray sandy clay	22	145
Medium to coarse loose sand	155	300
Coarse sand with small fragments of clay and dark grains of phosphate	70	370
Coarse clear sand with a few small dark grains of phosphate (?) and a few fragments of shell	20	390
Very coarse clear sand with a few dark grains of phosphate and numerous fragments of shells	5	395
Medium-grained, slightly argillaceous sand with a few fragments of shells	15	410
Very coarse clear sand with small dark grains of phosphate (?) and numerous fragments of shells	25	435
Coarse clear sand with numerous fragments of shells	25	460
Coarse sand cemented with lime and numerous fragments of fossils, chiefly Balanus sp.	20	480

Dr. Vaughan provisionally refers the lowermost layer to the Miocene.

Barrington.—A deep well at Barrington is described by McCallie [1] as follows:

The deep well at Barrington, sunk by the Atlantic Coast Line Railroad in 1895 for the purpose of securing water to supply its locomotives, is 3 inches in diameter and 450 feet deep. It furnishes 200 gallons of water per minute and the water rises 20 feet above the surface. Two flows are reported in the well, one at 350 feet and the other at 450 feet. The formations penetrated are said to be similar to those in the Brunswick wells.

Wolf Island.—A well at Wolf Island is described by McCallie [2] as follows:

This well was completed in 1891 at a cost of $500. It is a 2-inch well, 500 feet deep. The water, which is strongly sulphureted, rises 45 feet above the surface. No record of the well has been preserved.

Creighton Island.—A well at Creighton Island is described by McCallie [2] as follows:

The Creighton Island well, owned by Mr. George E. Atwood, has a depth of 414 feet. It is 3 inches in diameter and furnishes a flow which rises 50 feet above the surface. A dark-colored rock, 20 feet in thickness, is reported to have been struck in this well at 320 feet. Samples of this rock were found to be impure manganese ore. Coral rock and beds of gravel are said to have occurred in the well, but neither their depth nor their thickness was given.

Doboy.—A well at Doboy is described by McCallie [2] as follows:

Mr. J. C. Woodhull's well at Doboy is 128 feet deep and furnishes a flow which rises 10 feet above the surface. This well is interesting, as it is the only deep well in the county where a flow is obtained near the surface. The water-bearing stratum furnishing this flow probably occurs in other deep wells in the county, but its presence has not been reported.

[1] Georgia Geol. Survey Bull. 15, p. 149, 1908. [2] Idem, p. 150.

TABLE 59.—*Wells in McIntosh County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Barrington	Atlantic Coast Line R. R.		S. W. McCallie [a]	1895	
2	Creighton Island	G. E. Atwood		do		
3	Crescent	Georgia Coast & Piedmont R. R.				
4	Darien	Town		S. W. McCallie [a]	1891	30
5	do	do		do	1885	
6	do	do		J. G. Legare		
7	Darien, 300 yards northwest of post office.	R. Manson		Owner		
8	Darien, about 1½ miles south of, on Butler Island.	Adam Strain estate	T. A. Bailey	Chas. M. Tyson	1908	Near.
9	Doboy	J. C. Woodhull		S. W. McCallie [a]		
10	Doboy Island	Hilton & Dodge Lumber Co.		R. D. Fox	1890?	15
11	Eulonia, 3 miles northeast of.	J. A. Walker	Jule Atwood	G. H. Bacon, postmaster.		
12	Egg Island	Mrs. W. A. Wilcox				
13	Inverness (Blackbeard Island).	Quarantine station		A. C. McKinley		
14	Inverness (Little Sapelo Island).	J. H. Banoly		do		
15	Ridgeville	Wm. Clifton	Mr. Ray	Wm. Clifton	1890	
16	Ridgeville, 400 yards south of post office.	J. F. Thompson	T. A. Bailey	Owner	1908	12
17	Ridgeville, ½ mile northeast of.	Thos. A. Bailey	do	do	1896	20
18	Ridgeville, ½ mile southeast of.	P. S. Clark	Mr. Howe	do	1896	
19	Sapelo light station	U. S. Government	Fred Baumgartner, Brunswick.	Driller	1906	
20	Valona, 100 yards east of post office.	G. E. Atwood	Mr. Mulligan	Owner	1898	8
21	Wolf Island	Wolf Island Club			1891	

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Height of water above surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	450	3	450	350	20	200		Flows	Hard.
2	414	3			50			do	
3								do	
4	530	8	530		15	200		do	See analysis, p. 324.
5	492	4				35		do	
6	485	2				40		do	
7	405		405		22			do	
8	500	3	500	365	20	30		do	
9	128				10			do	
10	485	2			15			do	Sulphurous.
11	300+							do	
12								do	
13								do	
14	300±							do	
15	527	4	500		16			do	Soft.
16	503	2½	475		13	5		do	Sulphurous.
17	476	2½	454–476		18	20		do	
18	474	2	474		25			do	Slightly hard.
19	480								
20	455	3			35			Flows	Sulphurous.
21	500	2			45			do	Do.

[a] Georgia Geol. Survey Bull. 15, pp. 149–150, 1908.

TABLE 59.—*Wells in McIntosh County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Locomotive	Tertiary		
2	do	do		
3	do	do		One well.
4	Domestic	do	Sand	See log, pp. 324-325.
5	do	do		
6	do	do		
7	Domestic	do		
8	Domestic, canning fruit, etc.	do	Gravel	3-inch casing to 365 feet. Cost of well, $400. The estate owns 2 other similar wells.
9	do	do		
10	Domestic and boiler supply.	do		Cost of well, $300. The company owns another similar well on Doboy Island.
11	Domestic	do		
12	do	do		One well.
13	do	do		Two wells.
14	do	do		
15	Domestic, irrigation.	do		Formerly flowed +26. Cost of well, $1,350.
16	Domestic	do	Sand	2-inch casing to 100 feet. Cost of well, $350.
17	do	do	Gravel	2½-inch casing to 160 feet.
18	do	do	Quicksand	Cost of well, $150.
19	do	Miocene?	do	See log, p. 326.
20	Domestic and boiler supply.	Tertiary	Limestone	Cost of well, $150. See log, p. 325.
21	do	do		

MACON COUNTY.

GENERAL FEATURES.

Macon County is in the northwestern part of the Coastal Plain of Georgia. Its area is 369 square miles and its population (census of 1910) is 15,016. Agriculture is the chief industry.

TOPOGRAPHY.

The county is part of the physiographic division of the fall-line hills. The original upland plain has been largely destroyed by the erosion of Flint River, which crosses the county from north to south, and by its various tributaries. In the northeastern part, however, considerable stretches of the original plain remain.

Along the sides of Flint River valley lie two relatively narrow Pleistocene terrace plains, one 15 to 20 feet and the other 50 or 60 feet above low-water level of the river. The maximum surface relief probably does not exceed 300 feet.

GEOLOGY.

Cretaceous strata underlie the whole county but come to the surface only in the northeast over about one-third the total area. Lower Cretaceous strata, which consist of coarse, irregularly bedded, arkosic sands and clays, outcrop farther north, in the adjoining county of Taylor, and dip slightly southward, passing beneath Upper Cretaceous deposits near the northern border of Macon County.

The Lower Cretaceous strata are unconformably overlain by the Ripley formation of the Upper Cretaceous. The Cusseta sand member of the Ripley formation, which consists of several hundred feet of irregularly bedded sands and clays of shallow-water origin, forms the basal portion of the formation. The Cusseta member is conformably overlain by several hundred feet of typical marine beds of the formation, which consist of dark sands, clays, and marls. These beds have not been traced eastward beyond Ideal, but it is thought that they merge in that direction into irregularly bedded shallow-water equivalents. However, their buried representatives preserve the characters of the member much farther eastward, as shown by the records of wells at Montezuma and Marshallville. In the west the typical marine beds are overlain by the Providence sand member of the formation, which consists of 150 feet or more of irregularly bedded sands and clays of shallow-water origin. Eastward the member thickens and includes in its basal portions shallow-water representatives of the typical marine beds.

The Ripley formation is overlain unconformably by Eocene strata, which appear at the surface over the southern part of the county. The Eocene deposits consist of sands and clays belonging chiefly to the Midway formation of the Eocene. However, the Wilcox formation is probably represented in the southwestern part of the county and the Claiborne and Jackson formations are believed to be represented in the southeast. A thin overlap of ferruginous sands belonging to the Claiborne group conceals the Cretaceous beds in the northeastern parts of the county. (See Pl. III, p. 52.)

Thin Pleistocene terrace deposits overlie the Cretaceous and Eocene strata in narrow areas bordering Flint River.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Throughout the county supplies of water of good quality for domestic use are obtained chiefly from water-bearing beds in the Cretaceous or Eocene formation from dug, drilled, and bored wells 20 to 500 feet in depth and from springs. Springs are numerous throughout the greater part of the region but are commonly small. (See p. 332.) Creeks and small branches furnish excellent waters in great abundance for stock and for making steam.

Both the Cretaceous and Eocene formations are composed largely of beds of porous sand capable of retaining large quantities of water. The prospects are favorable, therefore, in all parts of the county for obtaining artesian supplies from Cretaceous or Eocene sources. At Montezuma and Oglethorpe the Cretaceous beds are probably reached at a depth not greater than 160 feet. Flowing wells at these

places yield large quantities of water from beds in the Ripley formation. In the extreme southern part of the county it would be necessary to drill through 150 feet or more of Eocene strata before entering the Cretaceous beds.

Flowing wells can probably be obtained on the lowest terrace bordering Flint River at elevations not exceeding 40 or 50 feet above low-water level from the point where the river enters the county on the north to the southern boundary.

LOCAL SUPPLIES.

Oglethorpe (population 924, census of 1910).—Oglethorpe, the county seat, is not provided with a water-supply system but owns a flowing artesian well in one of the business streets. (See Pl. XXI, *A*.) No log is available but the well undoubtedly taps a water-bearing bed in the Ripley formation of the Upper Cretaceous. This well is used as a public drinking place for persons and animals. McCallie says:[1]

> The deep well at Oglethorpe, the county seat of Macon County, which was sunk by the town authorities in 1894, has a depth of 500 feet and furnishes a strong flow. The strata penetrated in this well are said to be practically the same as in the Montezuma well.

An analysis of the water is given in Table 61 (analysis 4).

One other deep well at Oglethorpe is owned by Judge R. L. Greer, who furnishes the following information:

The well is about 1,250 feet northwest of the post office and 50 or 60 feet above low-water level of Flint River. It was drilled in 1909. Its depth is 446 feet and its diameter 3 inches from top to bottom, 3-inch casing having been used for the entire depth. When the well was first drilled the water flowed 2½ gallons per minute, 10 or 12 inches above the surface, through a 2-inch pipe inserted within the 3-inch casing. The 2-inch pipe was removed and the water dropped to 6 or 8 feet below the surface, where it now stands. The well is fitted with a hand pump and a gasoline engine. The water is said to be somewhat ferruginous and sulphurous, but is used for general domestic purposes. The cost was about $550.

Montezuma (population 1,630, census of 1910).—Montezuma owns a public water system, concerning which Mayor J. P. Walker furnishes the following information:

A pump with a capacity of 140 gallons per minute forces water obtained from flowing artesian wells to an elevated tank of 40,000 gallons capacity, from which it is distributed to the consumers. The plant is equipped with another pump, having a capacity of 500 gallons per minute, for applying direct pressure to the mains for fire protection. The tank pressure is 65 pounds and the direct pressure from the pump 75 pounds. The length of the distributing mains is

[1] Georgia Geol. Survey Bull. 15, p. 144, 1908.

A. PUBLIC FLOWING WELL AT OGLETHORPE, MACON COUNTY.

Photograph by S. W. McCallie.

B. FLOWING WELL AT MONTEZUMA, MACON COUNTY.

Static head is 60 feet above the surface. Photograph by S. W. McCallie.

4 miles; the number of taps for domestic purposes is 195; for manufacturing purposes, 10; and there are 45 fire hydrants. The amount consumed daily is 150,000 gallons. An analysis of the water is given in Table 61 (analysis 2).

McCallie[1] states that 18 flowing wells, from 60 to 500 feet, have been drilled at Montezuma (Pl. XXI, *B*). He gives a log of the deepest one:

Log of well at Montezuma (No. 3, Table 60).

[Authority, E. J. Wilson, contractor.]

	Thickness.	Depth.
	Feet.	*Feet.*
18. Sand	6	6
17. White clay	12	18
16. Limestone	2	20
15. Sand and clay	30	50
14. Bluish tough clay	10	60
13. Sand with mica	15	75
12. Blue clay	20	95
11. Sand and blue clay	60	155
10. Fine micaceous sand	5	160
9. Sand and clay	30	190
8. Sand with thin layers of flint	120	310
7. Clay and fossil wood	40	350
6. Limestone containing shells	2	352
5. Micaceous sand	4	356
4. Clay interstratified with sand	60	416
3. Fossiliferous limestone with layers of sand	64	480
2. Clay	16	496
1. Sand	4	500

McCallie says further:

The first water-bearing stratum, struck at 60 feet, flowed 8 feet above the surface; the second water-bearing stratum, struck at 150 feet, flowed 20 feet above the surface; the third water-bearing stratum, struck at 350 feet, flowed 30 feet above the surface; the fourth water-bearing stratum, struck at 500 feet, flowed 62 feet above the surface.

Three of the Montezuma wells obtain their water supply from the first stratum, 14 from the third, and 1 from the fourth. So abundant is the flow from the deep wells that an attempt was made to use the water to furnish power to operate a cotton gin, but the attempt was not successful. The total amount of water furnished daily by these wells is very great, and it must necessarily cause a very heavy draft on the water supply. Nevertheless, it is stated that there has not yet been any perceptible variation in the static head.

No fossils were preserved, so that an attempt to distinguish the formations penetrated can be nothing more than a rough guess based upon the descriptions of the materials as furnished by the driller. Layer 18 is probably Pleistocene terrace sand; layers 10 to 17, inclusive, are believed to belong to the Midway formation of the Eocene, although considerations based upon the depth at which the Cretaceous is struck in wells at Americus, Sumter County, throw some doubt upon this interpretation; layers 1 to 9, inclusive, probably belong to the Ripley formation of the Upper Cretaceous. Layers 1 to 6, inclusive, probably represent the eastward buried extension of the typical marine beds of the Ripley formation. If these correlations

[1] Georgia Geol. Survey Bull. 15, pp. 142, 143, 1908.

are correct the water-bearing strata at 60 and 150 feet are in the Midway formation, and those at 350 and 500 feet are in the Ripley formation of the Upper Cretaceous.

Six miles north of Montezuma.—C. L. De Vaughn owns a well west of Flint River on the lowest Pleistocene terrace plain, 6 miles north of Montezuma. The well is 125 feet deep and is cased to 90 feet. The water flows 20 feet above the surface. The water-bearing stratum tapped is in the Ripley formation of the Upper Cretaceous, and the water is said to come from a bed of sand beneath a layer of clay. An analysis is given in Table 61 (analysis 3).

Marshallville (population 1,082, census of 1910).—The town of Marshallville does not own a municipal water-supply system. An attempt was made in 1901 to obtain a public supply from an artesian source, but on account of difficulties of construction the well was abandoned. The following account is furnished by McCallie:[1]

> The deep well at this place, put down by the town council in 1901 at a cost of about $1,200, has a depth of 397 feet. It is a 6-inch well, reduced to 3 inches near the bottom; it furnishes about 3,000 gallons per hour, the capacity of the pump. The water rises to within 121 feet of the surface.

McCallie gives the following log:

Log of abandoned town well at Marshallville (No. 1, Table 60).

	Thickness.	Depth.
	Feet.	*Feet.*
Yellow clay	25	25
Sand with some pipe clay	65	90
Fine gray sand	95	185
Brownish sandy clay	45	230
Fine gray sand	40	270
Sand and blue marl	50	320
Clay	50	370
Thin layers of limestone	10	380
Very hard rock	10	390
Sand (water bearing)	7	397

The upper 25 feet of the materials described in the preceding log should probably be referred to the Claiborne group of the Eocene. The strata from 25 to 370 feet probably belong to the Providence sand member of the Ripley formation; those from 370 to 397 feet are believed to represent the eastward buried extension of the typical marine beds of the Ripley formation.

One other well, reported from Marshallville, is owned by the Varn & Platt Co., of Savannah (No. 2, Table 60).

Miona Springs.—Miona Springs is a group of small springs in a swamp bordering Flint River, 10 miles north of Oglethorpe. They are owned by the Miona Mineral Springs Co., of Fort Valley. The waters have reputed medicinal properties and the place is being conducted as a resort, hotel accommodations and cottages having been erected. The largest of the group yields 20 gallons per minute.

[1] Georgia Geol. Survey Bull. 15, pp. 144, 145, 1908.

TABLE 60.—*Wells in Macon County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Marshallville	Town		S. W. McCallie[a]	1901	500
2	Marshallville, 250 yards south of post office.	Varn & Platt Co., Savannah, Ga.		Milton T. Herman, secretary Varn & Platt Co.	1909	500
3	Montezuma			S. W. McCallie[a]		300±
4	Montezuma, 6 miles north of.	C. L. De Vaughn				
5	Oglethorpe	Town	Joseph Wilson, Montezuma.	J. S. Elmore, ordinary, and S. W. McCallie.[a]	1894	300±
6	do	R. L. Greer		Owner	1909	300±

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	397	6	390–397		−121		125		
2	483	4	483		−120		75	Air-compressor pump.	
3	500		500	60, 150, 350	+ 62			Flows	See analysis 2, Table 61.
4	125		125		+ 20			do	See analysis 3, Table 61.
5	500		500		+ 36	70		do	See analysis 4, Table 61.
6	446	3	446		− 7			Hand pump and gasoline engine.	Slightly ferruginous and sulphurous.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Abandoned	Ripley formation	Sand	Diameter reduced to 3 inches near the bottom. See log, p. 332.
2	Canning fruit and drinking.	do		
3		do		Many flowing wells have been drilled at Montezuma. See log, p. 331.
4		do	Sand	
5	Drinking and domestic.	do	do	2-inch casing to 300 feet. Cost of well, $675.
6	Domestic	do		Originally flowed 2½ gallons 1 foot above surface. Cost of well, $550.

[a] Georgia Geol. Survey Bull. 15, pp. 142-145, 1908.

TABLE 61.—*Analyses of underground waters from Macon County.*

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	Apr. 21, 1911	Flowing well	Montezuma	Ripley formation.	375	Edgar Everhart.
2		City wells	do	do	500	Do.[a]
3	Apr. 21, 1911	Well of C. L. De Vaughn.	Montezuma, 6 miles north of.	do	125	Do.
4		Town well	Oglethorpe	do	500	H. C. White.[a]

[a] Georgia Geol. Survey Bull. 15, pp. 142-144, 1908.

TABLE 61.—*Analyses of underground waters from Macon County*—Continued.

[Parts per million.]

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	42	0.4	14	2.0	6.0		.....	50	5.0	0.1	4.0	.....	110	
2	40	[a]3.1	13	1.5	22	5.3	0.0	35	12	.....	6.8	.....	138	The municipal supply comes from the fourth water-bearing bed, the depth of which is 500 feet. Phosphate radicle (PO_4)=2.4. Well 3, Table 60.
3	20	18	6.4	1.6	8.0		.0	38	.0	1.5	2.5	.....	132	Well 4, Table 60.
4	2	.....	6.7	3.2	40		.....	10	67	.....	27	7	158	Well 5, Table 60.

[a] $Fe_2O_3+Al_2O_3$.

MARION COUNTY.

GENERAL FEATURES.

Marion County is in the northwestern part of the Coastal Plain of Georgia. Its area is 360 square miles and its population (census of 1910) is 9,147. Agriculture is the chief industry.

TOPOGRAPHY.

The county is included in the physiographic division of the Coastal Plain known as the fall-line hills. Its surface is hilly and forms part of a dissected upland plain. The county lies on the divide between Chattahoochee and Flint rivers, a part of the run-off being received by the former, through its tributary, Upatoi Creek, and the remainder passing into the latter through Whitewater, Bucks, Muckalee, and Kinchafoonee creeks. The maximum surface relief is probably not greater than 300 feet. The hills have rounded outlines and over much of the area their tops and slopes are blanketed with a thin covering of residual though more or less wind and torrent shifted sand.

GEOLOGY.

The materials which outcrop at the surface are in part Cretaceous and in part Tertiary. Along the extreme northwest border Lower Cretaceous sands and clays probably occupy small areas, for they outcrop in the southern part of the adjoining county of Talbot and dip slightly southeastward, disappearing beneath the Upper Cretaceous beds in the valley of Juniper Creek. The Lower Cretaceous deposits consist of several hundred feet of irregularly bedded, coarse arkosic sands with subordinate lenses of light massive clay. They rest upon crystalline basement rocks.

The Upper Cretaceous deposits have been referred in ascending order to the Eutaw and Ripley formations. The Eutaw formation

consists of irregularly bedded sands and clays of shallow-water origin. The Ripley formation, which conformably overlies the Eutaw, is divisible on lithologic grounds into the Cusseta sand member, which consists of several hundred feet of irregularly bedded sands and clays similar to the sediments composing the Eutaw formation, the typical marine beds of the Ripley formation, which consist of 450 or 500 feet of massive, compact, gray sands and clays, more or less calcareous and glauconitic, with indurated layers at intervals, and at the top the Providence sand member, which consists of about 150 feet of irregularly bedded sands and clays, mostly of coarse texture and of shallow-water origin. The Upper Cretaceous deposits all incline slightly to the southeast, the lower and older beds passing beneath the higher and younger beds.

The Upper Cretaceous deposits are unconformably overlain by sands and clays belonging to the Midway formation of the Eocene. (See Pl. III, p. 52.)

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug wells 15 to 140 feet deep, which tap water-bearing beds in the Cretaceous and Eocene deposits, are the chief source of domestic water supplies. Cribbing, generally of wood, is used to varying depths below the surface, depending upon the character of the materials. The water is commonly lifted by rope and bucket. In the outcrop of the typical marine beds of the Ripley formation the water from dug wells is apt to be more or less hard, ferruginous, and sulphurous. In the areas underlain by the Eutaw formation and by the Cusseta and Providence sand members of the Ripley formation the waters from dug wells are commonly soft and of good quality, although locally they are ferruginous and sulphurous. The log of one of the deeper dug wells follows, the owner being authority for the lithology:

Log of well of B. F. Duke, 8 miles northeast of Buena Vista.

	Thickness.	Depth.
Upper Cretaceous, Ripley formation, Cusseta sand member:	*Feet.*	*Feet.*
Very hard clay	12	12
Yellow sand	80	92
"Chalk" [clay]	12	104
Yellow sand, water bearing	36	140

Small springs of good quality are common throughout the county and where conveniently located are used for domestic supplies. The municipal water supply of Buena Vista is obtained from springs. (See p. 336.)

The Cretaceous formations outcrop successively in descending order from the latitude of Buena Vista to the northern border of the county, and all of them underlie its southern part. The physical structure of the Cretaceous strata, except the typical marine beds of the Ripley formation, which contain a considerable percentage of lime, glauconite, and iron pyrites, is favorable to the retention of large quantities of good water. The chances are good, therefore, for obtaining artesian supplies at reasonable depths in any part of the county. In order to tap the Cretaceous water-bearing beds in the south it is necessary to drill through a probable maximum of 250 feet of overlying Eocene strata. The Eocene beds probably carry moderate amounts of potable water. Flowing wells probably can not be obtained.

LOCAL SUPPLIES.

Buena Vista (population 1,016, census of 1910).—Buena Vista, the county seat, owns a public water system, data concerning which have been furnished by G. P. Munn and J. G. Lowe, both of Buena Vista. The supply is derived from Camp Ground Springs, a mile northwest of the town. The springs are at the head of a small valley and together yield 40 gallons per minute of clear, soft water. The water is pumped to a tank of 45,000 gallons capacity, located in the town, and is used for domestic purposes, fire protection, and sprinkling.

The springs emerge from the Providence sand member of the Ripley formation. An analysis is given in Table 62 (analysis 1).

Several attempts have been made to obtain artesian water. In one well 583 feet deep and 10 inches in diameter water rose to within 240 feet of the surface.[1] E. J. Wilson, the driller, furnished the following log:

Log of abandoned well at Buena Vista.

[Authority, E. J. Wilson.]

	Thickness.	Depth.
	Feet.	*Feet.*
Blue clays	35	35
Sand and clays	70	105
Soft limestone	50	155
Marl	3	158
Rock	1	159
Marl	93	252
Flint	2	254
Indurated marl	9	263
Hard rock	7	270
Marl	27	297
Limestone, water bearing	34	331
Coarse gray sand	12	343
Marl, water bearing	21	364
Marl	187	551
Hard, compact rock	32	583

[1] Georgia Geol. Survey Bull. 15, p. 146, 1908.

McCallie adds:

Two water-bearing strata are reported in the well, one at 331 feet and the other at 364 feet from the surface. The first of these beds is said to have yielded a large quantity of water, but it was found impossible to keep the bore hole from filling with quicksand. Several weeks were spent in trying to control the inflowing sand, but all efforts were unsuccessful. The quicksand was finally cased off and the well was continued to the depth of 583 feet, when the appropriation made by the town council was expended and the well was abandoned. The water-bearing strata of this well are Cretaceous.

The upper 105 feet of strata is referable to the Providence sand member of the Ripley formation, and the remainder of the section to the typical marine beds of the same formation.

Information concerning three unsuccessful attempts to develop a municipal water supply from an underground source at Buena Vista has been furnished by J. C. Butt, as follows:

Two of the wells were 240 feet deep and were cased to 219 feet with 8-inch casing; water was obtained in quicksand at 227 feet. The third well was 800 feet deep and had 10-inch casing to 280 feet, 8-inch casing to 360 feet, 6-inch casing to 760 feet, and 4½-inch casing to 800 feet. All three attempts failed because of the inability of the drillers to control the fine quicksand of the water-bearing beds. The total cost of the three attempts was $1,300.

The third well described by Butt is probably the one described by McCallie, although the two accounts differ as regards the depth of the well.

Dug wells 10 to 100 feet deep afford a part of the domestic water supply of the town. The largest supplies are said to come from depths of 30 to 40 feet, from which source the water is lifted by rope and bucket. Pumps are used in the deeper wells, which tap water-bearing beds in the Providence sand member of the Ripley formation.

Doyle.—Eugene Dane, of Friendship, Sumter County, owns a deep well 1 mile west of Friendship and 5 or 6 miles south of Doyle, Marion County. T. J. James, the driller, gives the following information regarding the well:

The well was drilled in 1910, is 296 feet deep, and is cased with 3-inch casing to 107 feet and with 2-inch casing the rest of the depth. Water rises to within 90 feet of the surface from a bed at the bottom of the well. The well is pumped with a gasoline engine and yields 8 gallons per minute. The cost was $325. The water is used for domestic purposes. The well taps a water-bearing bed at either the base of the Midway formation or the top of the Ripley formation.

Spring near Tazewell.—Mineral Spring, 4 miles northwest of Tazewell, has reputed medicinal properties. According to W. E. Pickard, of Tazewell, it is in a small valley and is owned by Stewart & Wall of Tazewell. A small quantity of ferruginous, sulphurous water is

emitted. There are two cottages on the grounds and facilities for bathing. During the summer months people from the surrounding region camp in the vicinity of the spring.

Spring near Putnam.—A spring of reputed medicinal properties, known as Mineral Spring and owned by Miss Ida Munro, rises in a grove on Springdale farm three-eighths of a mile west of Putnam. The owner states that the water emerges from sand through a 10-inch terra-cotta pipe inserted in the ground to a depth of 12 feet, and that a roof has been placed over the spring. The water is used only for drinking. The source of the spring is probably the Midway formation. An analysis of the water is given in Table 62 (analysis 2).

TABLE 62.—*Analyses of spring waters from Marion County.*

[Parts per million.]

	1	2
Silica (SiO_2)	5.4	4.4
Iron (Fe)	.2	7.0
Aluminum (Al)	.....	.5
Calcium (Ca)	5.6	2.5
Magnesium (Mg)	6.8	1.2
Sodium (Na)	21	5.6
Potassium (K)		2.6
Carbonate radicle (CO_3)	.0	.0
Bicarbonate radicle (HCO_3)	12	26
Sulphate radicle (SO_4)	Trace.	.7
Nitrate radicle (NO_3)	50	.....
Chlorine (Cl)	20	12
Total dissolved solids	103	50
Free carbon dioxide (CO_2)	.....	41

1. Water from one of Camp Ground Springs, 1 mile northwest of Buena Vista, which furnish the municipal water supply of Buena Vista. The springs emerge from the Providence sand member of the Ripley formation. Sample collected Apr. 20, 1911; Edgar Everhart, analyst.

2. Mineral spring at residence of Miss Ida Munro, Springdale farm, three-eighths of a mile west of Putnam. Source of spring, Midway formation. Analyzed in April, 1910, by Edgar Everhart.

MILLER COUNTY.

GENERAL FEATURES.

Miller County is in the southwestern part of the Coastal Plain of Georgia in the V-shaped area formed by the junction of Chattahoochee and Flint rivers. Its area is 253 square miles and its population is 7,986 (census of 1910).

TOPOGRAPHY.

The county lies within the physiographic division known as the Dougherty plain and presents the topographic features typical of that division. The general surface is nearly level, but has numerous lime-sink depressions. Surface streams are few, the drainage being partly by underground streams through lime sinks. No exact determinations of elevation have been made, but the greater part of the surface is probably 125 to 200 feet above sea level.

GEOLOGY.

The Vicksburg formation (Oligocene) is the surface terrane throughout the county. It consists of 300 feet or more of sandy, cavernous,

water-bearing limestones which weather to red or yellow residual sands and clays containing fragments and masses of flint. Outcrops of unweathered limestone are rare.

The Vicksburg formation is underlain by several hundred feet of undifferentiated limestones, sands, clays, and marls of Eocene age which contain water-bearing beds. Although no wells have penetrated below the Eocene within the county, it is believed that these deposits are underlain by 2,000 feet or more of sands, clays, and marls of Cretaceous age, which rest upon a deeply buried basement of ancient crystalline rocks. The Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The domestic water supply of the county is obtained chiefly from dug wells 30 to 50 feet deep. With the exception of a few wells which draw from the underlying unweathered limestones of the Vicksburg formation, the source of the water is the residual sands and clays which compose the surface materials to varying depths. Artesian wells have been drilled at Colquitt and at Babcock.

The few small springs in the county are unimportant as sources of water supply. The waters of streams and ponds are used locally for stock and for boiler supply.

Abundant supplies of potable water can be obtained from deep wells anywhere, and on the low lands bordering Spring Creek flowing wells can probably be obtained from the deeply buried Eocene or Cretaceous deposits at 500 to 1,500 feet. This statement is based on the known static head of deep wells in Early, Baker, and Calhoun counties.

LOCAL SUPPLIES.

Colquitt (population 600, census of 1910).—Colquitt, the county seat, owns a public water-supply system which obtains water from a deep well, completed in 1911, on low land near the Georgia, Florida & Alabama Railway in the eastern part of the town. The well is 246.5 feet deep and the water stands within 16 feet of the surface. The maximum yield by pumping is about 500 gallons a minute. J. G. Chason, the driller, furnishes the following log from memory:

Log of town well at Colquitt (No. 3, Table 63).

	Thickness.	Depth.
	Feet.	*Feet.*
Sand and clay, water bearing at base	60	60
Soft limestone, containing cavities	75	135
Hard limestone, containing water-bearing strata	55	190
A shaly formation in alternating hard and soft layers	56	246
Hard sandrock	.5	246.5

The principal water-bearing bed is said to be at 140 feet and is probably in the Vicksburg formation. A sample collected from this well December 23, 1912, was analyzed by Edgar Everhart as follows:

Analysis of water from town well at Colquitt.

	Parts per million.
Silica (SiO_2)	6.0
Iron (Fe)	.5
Calcium (Ca)	40
Magnesium (Mg)	2.5
Sodium and potassium (Na+K)	6.0
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	148
Sulphate radicle (SO_4)	Trace.
Nitrate radicle (NO_3)	.5
Chlorine (Cl)	3.5
Total dissolved solids	129

Another well drilled by the town in 1900 is said to be 400 feet deep. Water stands within 56 feet of the surface. The surface at the mouth of this well is much higher than at the mouth of the new well, which accounts for the difference in the static head. The water is hard and is used only for domestic purposes.

Babcock (population 402, census of 1910).—A well owned by the Babcock Bros. Lumber Co. at Babcock, a small town in the southern part of the county, is 300 feet deep. Water stands within 30 feet of the surface. It is used for domestic purposes and for stock, but is not suitable for boiler supply.

TABLE 63.—*Wells in Miller County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Elevation above or below datum.
						Feet.
1	Babcock	Babcock Bros. Lumber Co.		R. O. McNair	1901	
2	Colquitt	Town		O. O. Bush	1900	[a]+25
3	do	do	J. G. Chason	J. G. Chason	1911	[b]−20
4	Colquitt (1 mile south of).	R. W. Graw	do	do	1911	[c]+42 or 50
5	Colquitt (4 miles southeast of).	L. Cowart	do	do	1911	

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	300	4			30			Steam pump	Hard.
2	400	3		150	56		75	do	Ferruginous, sulphurous, hard.
3	246½	8	140		16		500	Suction pump	See analysis above.
4	78	4	75		30		8	Gasoline force pump.	Hard.
5	360	4½	300-350		65		6	do	Do.

[a] Datum, surface at railroad station.
[b] Datum, surface at courthouse.
[c] Datum, low-water level of Spring Creek.

TABLE 63.—*Wells in Miller County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Vicksburg formation.		Diameter at top 6 inches, at bottom 4 inches.
2	do	Eocene	Sand and rock	Cost of well $700; cost of machinery $200. Diameter at top 4 inches, at bottom 3 inches.
3	Municipal supply.	Vicksburg formation.	Limestone	8-inch casing to 135 feet, see log, p. 339.
4	Domestic	do	White limestone	4-inch casing to 60 feet. Cost of well $150.
5	Domestic, manufacturing.	Eocene?	Marl	4½-inch casing to 240 feet.

MITCHELL COUNTY.

GENERAL FEATURES.

Mitchell County is in the southwestern part of the Coastal Plain of Georgia. Its area is 548 square miles and its population is 22,114 (census of 1910). Agriculture and lumbering are the chief industries. Near Dewitt and Baconton the cultivation of pecans is an important and growing industry.

TOPOGRAPHY.

A nearly level plain, 5 to 15 miles wide and 150 to 170 feet above sea level, lies east of and approximately parallel to Flint River, which forms the western boundary of the county. This area, which falls within the physiographic division known as the Dougherty plain, is characterized by numerous lime sinks and lime-sink ponds and by the almost total absence of surface streams, the drainage being chiefly underground. In narrow areas bordering the river the plain is modified by two more or less clearly defined Pleistocene terraces, one lying 15 to 20 feet and the other 50 to 60 feet above low-water level.

The remainder of the county, in the east and southeast, is an upland estimated to be 300 to 375 feet above sea level, the surface of which is characterized by low rounded hills and broad shallow valleys. This area lies in the physiographic division called the Altamaha upland or long-leaf pine region. The Altamaha upland is separated from the Dougherty plain to the west by a relatively abrupt escarpment, which is expressed in the grade of the Atlantic Coast Line Railroad between Camilla and Pelham.

GEOLOGY.

The Vicksburg formation is the surface terrane throughout the greater part of an area 5 to 15 miles wide which borders Flint River and is coextensive with the Dougherty plain. It consists of 300 feet or more of cavernous water-bearing limestones, which weather at the surface to residual sands and clays containing fragments and

masses of flint. The unweathered limestones outcrop in places in the channel and banks of Flint River. The formation extends eastward and underlies the entire county.

The Chattahoochee formation, which consists of 100 feet or less of limestones, overlies the Vicksburg formation, and the residual sands and clays to which the limestones weather outcrop in the face of the escarpment which separates the Altamaha upland from the Dougherty plain and which extends northeast and southwest through the county. The Chattahoochee formation is overlain by the Alum Bluff formation, which consists of 100 feet or less of sands and clays and which also outcrops in a narrow belt in the escarpment.

The Alum Bluff formation is overlain by 75 feet or less of irregularly bedded sands and clays of undetermined age, which outcrop throughout the remainder of the Altamaha upland in the eastern and southeastern parts of the county.

Thin terrace deposits of sand and clay of Pleistocene age occupy narrow areas bordering Flint River.

The Vicksburg formation is underlain by several hundred feet of undifferentiated limestones, sands, clays, and marls of Eocene age, which contain water-bearing beds. No definite confirmatory evidence is available, but it is believed that the Eocene deposits are underlain by 2,000 feet or more of sands, clays, and marls of Cretaceous age, which rest upon a basement of ancient crystalline rocks and which doubtless contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug wells, 20 to 50 feet deep, are the chief source of domestic water supply. Most of them yield soft waters, although in the western part of the county some penetrate the unweathered limestones of the Vicksburg formation and yield hard waters. During times of drought some of the shallow wells fail.

Deep wells have been drilled at Camilla, Pelham, and Flint.

Limestone springs emerging from the Vicksburg formation occur along Flint River. Seepage springs are abundant in the eastern part of the county in the region of outcrop of the Alum Bluff formation and the overlying sands and clays. Springs, however, are relatively unimportant.

Artesian water can be obtained anywhere at depths of 100 to 1,500 feet or more. Waters from the Vicksburg formation, which in the western part of the county extends from the surface to a depth of 300 feet or more, and which in the east would probably be encountered at depths of 200 to 500 feet, will be hard. Those obtained at greater depths from the Eocene or Cretaceous deposits might be softer than the Vicksburg waters.

Although no flowing wells have been reported, it is believed that flows can be obtained on the Dougherty plain in the west at depths of 500 to 1,500 feet or more. In the region of the Altamaha upland in the east flowing wells probably can not be obtained.

LOCAL SUPPLIES.

Camilla (population 1,827, census of 1910).—A well owned by the city, completed in 1904, is 297 feet deep and yields hard water, which stands within 50 feet of the surface. The well is said to penetrate chiefly limestones, probably belonging to the Vicksburg formation, from 100 feet to the bottom. Water is pumped at the rate of 300 gallons per minute, an amount sufficient for the needs of the town. The following analysis of a sample collected from this well June 7, 1911, was made by Edgar Everhart:

Analysis of water from city well at Camilla.

	Parts per million.
Silica (SiO_2)	23
Iron (Fe)	.8
Calcium (Ca)	46
Magnesium (Mg)	1.0
Sodium and potassium (Na+K)	3.0
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	150
Sulphate radicle (SO_4)	5.0
Nitrate radicle (NO_3)	.4
Chlorine (Cl)	2.0
Total dissolved solids	137

Another well owned by the town is 396 feet deep (No. 1, Table 64).

Pelham (population 1,880, census of 1910).—The public water supply at Pelham is obtained from a drilled well 728 feet deep. The elevation at the mouth of the well is 355 feet above sea level and the water is said to stand within 215 feet of the surface. The water is moderately hard, but is considered satisfactory for general purposes.

J. H. Chandler, one of the drillers, furnishes the following log:

Log of town well, Pelham.

	Thickness.	Depth.
	Feet.	*Feet.*
Clay in hard and soft layers	153	153
Hard "soapstone"	22	175
Hard gray rock with flint bowlders	195	370
Very hard "granite" rock, water bearing in upper 1 foot	80	450
Shell formation, water bearing	5	455
Hard "quartz" rock	185	640
Shell formation, water bearing	10	650
Gray granite	50	700
Shell formation, water bearing	28	728

McCallie [1] mentions a well at Pelham 293 feet deep, in which limestone probably belonging to the Chattahoochee formation was struck at 180 feet.

[1] Georgia Geol. Survey Bull. 15, p. 147, 1908.

Flint (population 105, census of 1910).—According to T. B. White, postmaster, four nonflowing wells at Flint range in depth from 180 to 700 feet.

TABLE 64.—*Wells in Mitchell County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Camilla	Town	M. A. Jarrard	Lena Brimberry		177
2	do	do	J. D. Pitts	T. B. Perry	1904	167
3	Flint	G. C. Cochran		Thos. B. White		168
4	Pelham (½ mile north of).	Town?	F. T. White & Co.; J. H. Chandler and C. E. Edwards drillers in charge.	J. H. Chandler and the mayor.		355

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	396	8	396		50		500	Air-lift pump	Hard.
2	297	8	297	140	50		300	do	Hard; see analysis, p. 343.
3	180	3						Hand pump	Soft.
4	728	10	700–728	370–371 450–455 640–650	215		350	Air-compressor pump	Moderately hard.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic, manufacturing.	Eocene?	Limestone	8-inch casing to 396 feet. Cost of well, $1,200; of machinery, $1,000.
2	Domestic, manufacturing, boiler supply.	Vicksburg formation.	Rock	8-inch casing to 210 feet.
3	Domestic	do		4 deep wells at Flint from 180 to 700 feet deep.
4	Municipal supply.	Eocene	Shell formation	153 feet of 10-inch casing. See log, p. 343.

MONTGOMERY COUNTY.[1]

GENERAL FEATURES.

Montgomery County is in the central part of the Coastal Plain of Georgia. Oconee River, which flows through its center, and Ocmulgee River, which forms part of its southern boundary, unite at the southeast corner to form Altamaha River. The area of the county is 591 square miles and the population is 19,638 (census of 1910).

[1] Under this heading is included a portion of Montgomery County which has been segregated and organized as Wheeler County since this report was transmitted for publication.

The production of lumber and naval stores and the cultivation of cotton and corn are the principal industries.

TOPOGRAPHY.

The interstream areas are rolling to hilly, forming a part of the physiographic division known as the Altamaha upland. Although few exact determinations of level have been made, it is probable that the upland lies 250 to 300 feet above sea level. Low-water level at the junction of Oconee and Ocmulgee rivers is approximately 80 feet above sea level. Each of the rivers named is bordered by two more or less clearly defined Pleistocene terrace plains, one 10 to 20 feet and the other 40 to 50 feet above low-water level. The lower plain is covered in part by swamps and is subject in part to overflow. Little Ocmulgee River, which forms the western boundary, is bordered on the east by a belt of sand hills, one-half to 1½ miles wide, rising 50 to 75 feet above the streams. Cypress ponds and tracts of densely wooded seepage areas known as bays at the heads of branches and creeks are common in the south.

GEOLOGY.

The surface deposits throughout the interstream areas consist of 100 feet or less of irregularly bedded sandy clays and sands with subordinate interbedded layers of argillaceous sandstone. They are underlain by 100 feet or more of soft sandy clays and sands, in part water bearing, with interbedded thin layers of sandstone and quartzite that belong to the Alum Bluff formation. These strata outcrop in the valleys of Oconee, Ocmulgee, and Little Ocmulgee rivers.

The Alum Bluff formation is underlain by 400 feet or more of limestones with interbedded layers of calcareous sandstone and marl (see log, p. 346), which probably represent in descending order the Chattahoochee and Vicksburg formations of the Oligocene and perhaps the Jackson formation of the Eocene. These formations contain water-bearing beds.

Beneath the limestones in descending order are a series of sediments of Eocene and Cretaceous age which probably have an aggregate thickness of 1,500 feet or more and which rest upon a basement of ancient crystalline rocks. These deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug wells 20 to 50 feet deep are the chief sources of water for domestic use. Artesian wells have been drilled at Mount Vernon, McArthur plantation, Higgston, Ochwalkee, and near Soperton.

Small seepage springs occur throughout the county but are of little importance. The waters of many of them, especially those in the swamps, after contact with the air have a film of iron oxide over the surface and taste strongly of iron. (See analyses 1 and 2, Table 66.) The water of streams and ponds can be used for stock and for boiler supply.

Artesian water can be obtained anywhere at depths of 100 to 1,500 feet or more. Flows can be obtained on the terrace plains bordering Ocmulgee and Oconee rivers and in the valleys of their large tributaries.

LOCAL SUPPLIES.

Mount Vernon (population 605, census of 1910).—The town has a public water-supply system, owned by W. C. McRae and others, which draws from a flowing artesian well 300 feet deep. The water is reported hard. The daily consumption is 7,000 gallons.

McArthur plantation.—The McArthur plantation is in the southern part of Montgomery County about 5 miles northeast of Lumber City (Telfair County). An artesian well at this place is 900 feet deep, and the water rises to within 60 feet of the surface. The water is soft and for general purposes is superior to the artesian waters from more shallow depths in this part of the Coastal Plain. (See analysis 3, Table 66.) McCallie [1] has published the following log:

Log of well on McArthur plantation (No. 2, Table 65).

	Thickness.	Depth.
	Feet.	*Feet.*
Sandy soil	4	4
Red clay	16	20
Coarse sand	10	30
Blue clay with thin layers of sandstone	220	250
Sand	100	350
Limestone, water bearing at 419 feet	150	500
Flint	2	502
Sandstone	23	525
Shell formation	100	625
White limestone, water bearing at base	265	890
Not reported	10	900

The well probably penetrates to the lower part of the Eocene deposits.

Higgston (population 207, census of 1910).—The principal sources of water supply at Higgston are shallow dug wells. An artesian well, owned by T. M. Barker, is 353 feet deep and contains water that rises to within 73 feet of the surface. An analysis of water from a small spring near Higgston, owned by Mr. W. R. Calhoun, is given in Table 66 (analysis 1).

[1] Georgia Geol. Survey Bull. 15, pp. 150, 151, 1908.

Ochwalkee.—Ochwalkee is a small station on the Seaboard Air Line Railway on the west side of Oconee River. An artesian well near the station, owned by the Hilton & Dodge Lumber Co., is 228 feet deep and flows 20 feet above the surface.

Soperton (population 449, census of 1910).—J. F. Wooten, a well contractor, states that a flowing artesian well on the A. B. Conner estate, 7 miles southwest of Soperton, is 240 feet deep. Its mouth is about 25 feet above the level of Oconee River, and the water, which rises 8 feet above the surface, flows 25 gallons a minute. The principal water-bearing bed is said to be a soft rock at 235 feet. The water is used for domestic purposes and for boiler supply at a sawmill.

McRae.—Two flowing wells a mile east of McRae (Telfair County) on the east side of Little Ocmulgee River near the wagon bridge, in Montgomery County, are reported to be 140 feet deep.

Kibbee.—An analysis of water from a small spring near Kibbee, owned by Mrs. N. H. Mason, is given in Table 66 (analysis 2).

TABLE 65.—*Wells in Montgomery County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Higgston	T. M. Barker		S. W. McCallie [a]	1902	
2	McArthur plantation, 5 miles northeast of Lumber City.			do		247
3	McRae (Telfair County), 1 mile east of.					
4	Mount Vernon	W. C. McRae and others.		Postmaster		
5	Ochwalkee	Hilton & Dodge Lumber Co.		S. W. McCallie [a]		
6	Soperton, 7 miles southwest of.	A. B. Conner estate	J. F. Wootten	J. F. Wootten	1910	[b]

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	353	6			−73				
2	900	3	890–900	419	−60				See analysis 3, Table 66.
3	140							Flows	
4	300				+17			do	Hard.
5	228	3			+20	25		do	
6	240	2½	235		+ 8	25		do	Sulphurous.

[a] Georgia Geol. Survey Bull. 15, pp. 150–151, 1908.
[b] Elevation about 25 feet above low-water level of Oconee River.

TABLE 65.—*Wells in Montgomery County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	.....	Oligocene?.....	.....	
2	.....	Eocene?.....	.....	Limestone at 350 feet. See log, p. 346
3	.....	Alum Bluff formation?	.....	Another similar well.
4	Municipal supply.	Vicksburg formation?	.....	
5	Domestic.....	Vicksburg formation.	.....	
6	Domestic, boiler supply.	.....do.....	Soft rock.....	2½-inch casing, 170 feet; 4-inch casing, 40 feet. Cost of well, $350.

TABLE 66.—*Analyses of underground waters from Montgomery County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	.....	Spring of W. A. Calhoun.	Higgston (near)...	Surficial deposits.	.....	Edgar Everhart.
2	Oct., 1909	Spring of Mrs. N. H. Mason.	Kibbee.....	Alum Bluff formation?	.....	Do.
3	Apr. 17, 1911	Well.....	McArthur plantation, 5 miles northeast of Lumber City.	Eocene?.....	890-900	Do.

No.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	10	30	Tr.	0.7	0.1	1.9	Tr.	.....	36	Tr.	.....	2.8	.....	86	
2	12	.5	0.2	1.6	.6	1.5	0.8	.....	33	1.4	.....	4.0	.....	27	
3	17	1.4	.....	16	4.0	32		1.0	159	2.0	0.1	9.0	.....	183	Well 2, Table 66.

MUSCOGEE COUNTY.

GENERAL FEATURES.

Muscogee County is in the western part of Georgia on the border between the Piedmont Plateau and the Gulf Coastal Plain. Its area is 235 square miles and its population (census of 1910) is 36,227. Columbus, the county seat, is its only municipality. The chief industries at Columbus are the manufacture of cotton goods, the extraction of cottonseed oil, the manufacture of carriages, wagons, and implements, and the manufacture of fertilizers. Outside of Columbus agriculture is the chief industry.

TOPOGRAPHY.

More than the southern half of the county is in the Gulf Coastal Plain and the remainder is in the Piedmont Plateau. The surface

in general is hilly. The Piedmont portion of the area is more rugged and slightly higher than the Coastal Plain portion. The Coastal Plain area is in the main a strongly dissected upland plain and is included in the physiographic division of the Coastal Plain known as the fall-line hills. In limited areas bordering Chattahoochee River, from Columbus southward, the hilly upland topography has been modified by Pleistocene terracing processes, which have produced two terrace plains, one (the Satilla) lying 40 or 45 feet above low-water level of the river and the other (the Okefenokee) lying 135 or 140 feet above the same datum. The greatest recorded altitude in the county is in the Piedmont area in the vicinity of Fortson, about 11 miles north of Columbus, where the elevation above sea level is 650 feet. Elevations as great as 550 feet are recorded in the northern part of the portion of the county in the Coastal Plain.

The county is drained by Chattahoochee River, the principal tributaries of which are Upatoi, Bull, and Standing Boy creeks. The maximum topographic relief is approximately 400 feet.

GEOLOGY.

Crystalline rocks appear at the surface in the Piedmont Plateau in the northern part of the county in an irregular belt 2 to 10 miles wide. The crystalline rocks dip southward 50 to 60 feet to the mile and pass beneath the deposits of the Coastal Plain, forming the base upon which the latter rest.

The Lower Cretaceous deposits, which constitute the greater part of the sediments of the Coastal Plain, consist of coarse arkosic sands and gravels, with interbedded lenses of light drab to white massive clays, which rest upon the crystalline basement rocks. The deposits, which attain a maximum thickness of 350 or 400 feet along the southern edge of the area, pass southward unconformably beneath the Eutaw formation of the Upper Cretaceous. The Lower Cretaceous deposits carry large quantities of water of excellent quality. The Eutaw formation outcrops in an irregular detached area 1 or 2 miles wide and about 10 miles long, north of Upatoi Creek, capping the hills to a maximum thickness of about 140 feet. The formation consists of sands and clays more or less calcareous and glauconitic. (See Pl. III, p. 52.)

A Pleistocene terrace plain (the Satilla), lying 40 or 45 feet above low-water level and having a width of 1 to 2½ miles, borders Chattahoochee River in the west. This plain is the upper surface of a Pleistocene terrace deposit of clays, loams, sands, and gravels 20 to 40 feet thick, which rests upon the planed-off surface of Lower Cretaceous strata. Small areas of a similar but older terrace plain (the Okefenokee) northeast and east of Columbus, 135 to 140 feet above

the low-water level of the river, also rest upon planed-off Lower Cretaceous strata. Coarse sands and gravels at the base of the Pleistocene deposits carry large quantities of water.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Outside the corporate limits of Columbus, in the Coastal Plain, water for domestic purposes is obtained chiefly from dug wells, few of which exceed 100 feet in depth. On the terraces bordering Chattahoochee River the wells, as a rule, do not exceed 30 or 40 feet in depth and derive their supplies from the sands and gravels at the base of the Pleistocene terrace deposits. In the hilly region east of the Chattahoochee Valley it is necessary at many places to sink the wells to greater depths.

Small springs are common in the hilly portions of the county and are used to some extent. Numerous small creeks and brooks furnish an abundant supply of excellent water for stock and for steam production.

The waters of both wells and springs are soft and, unless insanitary conditions exist at the surface in their immediate vicinity, are of excellent quality for domestic uses. Shallow wells and springs near stables or dwellings are liable to pollution unless the water-bearing strata are protected from surface seepage by overlying impervious strata of clay or rock and unless water-tight cribbings and casings extend from the surface down to such protecting strata.

The Lower Cretaceous deposits carry large quantities of soft water, except along the northern border of the Coastal Plain, where the terrane feathers out against the crystalline rocks of the Piedmont. The quantity of water contained in the formation increases down the dip of the beds, and in the extreme southwestern part of the county the amounts available are very great.

The maximum thickness of the deposits in the extreme southwest is estimated to be about 375 feet. Test wells near the mouth of Bull Creek draw from Lower Cretaceous beds. If these wells were 3 or 4 miles farther south they would probably supply much larger quantities.

Flowing wells can be obtained on the lowest Pleistocene terrace bordering the river from Bull Creek southward to Upatoi Creek and probably in the bottom lands of Upatoi Creek for several miles above its junction with the river.

LOCAL SUPPLIES.

Columbus (population 20,554, census of 1910).—Columbus is provided with a water-supply system, owned by the Columbus Water-

works Co. The following information was furnished by Maj. W. S. Greene, of Columbus, who was acting as receiver for the company.

The municipal water supply is derived in part from two spring branches in Lee County, Ala., 4 miles west of the city, and in part from Chattahoochee River; that derived from the former source is impounded in two reservoirs having a combined capacity of 63,000 gallons. From these reservoirs the water is conducted through a 12-inch pipe by gravity to settling basins at the filtration plant in the city. The portion derived from Chattahoochee River is lifted by means of an electric pump to the settling basins, where the mixed water from both sources is treated with alum as a preliminary to filtration, which is done with four units of the rapid sand type, manufactured by the New York Continental Jewell Filtration Co., each with a daily capacity of 500,000 gallons. After filtration the water passes into two clear-water basins having a combined capacity of 120,000 gallons, from which it is forced by an electric pump having a capacity of 1,200 gallons per minute into the standpipe whose base is 85 feet above the terrace plain upon which the business part of the city is situated. The standpipe itself is 120 feet high and has a capacity of 280,000 gallons. The standpipe pressure is 85 pounds and the direct pressure 100 pounds per square inch. The total length of the distributing mains is 30½ miles; the number of taps for domestic purposes is 2,241, and for manufacturing purposes 55; there are 174 fire hydrants. The daily consumption for domestic purposes is 925,000 gallons, and for manufacturing purposes 425,000 gallons. The water derived from the spring branches is soft.

During recent years a determined effort was made by the Hudson Engineering Co., of New York City, under contract with the city of Columbus, to secure sufficient water from an underground source to supply the city. The contract specified that the well or wells must show an output of 5,000,000 gallons daily during one week of continuous pumping. The place selected for the test wells was a tract of land on either side of Bull Creek, near its junction with Chattahoochee River, about 2½ to 3½ miles southeast of the post office. The surface here is part of the lowest Pleistocene terrace plain bordering Chattahoochee River, the general elevation of which is about 50 feet above low-water level of the river and between 230 and 240 feet above sea level.

N. W. Wood, constructing engineer, who had immediate charge of the work for the company, furnished the information here given concerning the results of the undertaking. The last detailed information received from Mr. Wood was in February, 1911, at which time 36 8-inch wells had been completed. The work was still in progress and several additional wells were contemplated. Data regarding the 36 wells are given in the following table:

Data of test wells near Columbus.

No. of well.	Total depth.	Depth to basement rock.	Approximate elevation of mouth of well above sea level.	No. of well.	Total depth.	Depth to basement rock.	Approximate elevation of mouth of well above sea level.
	Feet.	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*
1 [a]	250	173	218?	20	262	224	232.5
2	255	188	226.75?	21	262.5	225	232.25
3	260	203	233?	22	263	227	230
4	257	198	233.25	23	262	230	230.5
5	260	210	233.5	24	262	228	228.75
6	270	190	234.75	25	267	245	226.5
7	265	200	235	26	267	242	227
8	250	180	220.25?	27	225	225	230.25
9	266.5	180	224.25	28	216	216	228
10	260	171	233.75	29	241	241	552
11	261	173	232.75	30	222	222	222
12	262	185.5	232.5	31	247	247	232.75
13	248	195	231.5?	32	248	248	234.75
14 [b]	260	211.5	234.75	33 [e]			242.25
15	275	218	230.25	34	227.6	227.6	224.75
16 [c]	296	201	232	35	282	232	217.25
17 [d]	261	215	233.25	36 [f]	300	222	217.75
18 [d]	262	231	233	37	293	223	226.75
19 [d]	262	225	233.5				

[a] One water horizon only, 98 to 103 feet.
[b] Also known as No. 5A.
[c] Trace of gas in granite.
[d] Flowed about 10 gallons a minute when first drilled.
[e] A proposed well.
[f] Slight surface flow from rock.

The distribution of wells 1 to 26 is shown in figure 4. The exact location of the remaining 10 wells has not been learned, but they are south of Bull Creek, in the southeastern part of the area shown on the map.

The wells range in depth from 216 to 300 feet and the crystalline basement rocks were struck at depths of 171 to 248 feet. The logs of two of the wells follow:

Log of test well No. 11, at Columbus.

	Thickness.	Depth.
Lower Cretaceous (except about 25 feet of undifferentiated Pleistocene material at top):	*Feet.*	*Feet.*
Clay	56	56
Soft sand rock	4	60
Harder sand rock	34	94
Sand, with small amount of water	10	104
Clay, light in color	3	107
Sand	4	111
Clay, light in color	6	117
Hard sand	9	126
Red clay	10	136
Sand, water bearing	9	145
Red clay	10	155
Sand, water bearing	3	158
Yellow clay	2	160
Sand rock	13	173
Basement rocks:		
Decayed top of crystalline rock	29	202
Hard crystalline rock	59	261

Log of test well No. 25, near Columbus.

	Thickness.	Depth.
	Feet.	*Feet.*
Pleistocene (terrace deposit):		
Clay	17	17
Sand and gravel	10	27
Lower Cretaceous:		
White sand rock	4	31
Brown sand rock	7	38
White sand rock	8	46
Brown sand rock	9	55
Gray sand rock	14	69
Brown sand rock	8	77
Yellow sandy clay, soft and sticky	21	98
White sand, water bearing	19	117
White sandy clay, sticky like putty	8	125
Dark yellow clay	9	134
Blue sandy clay	8	142
Yellow clay	5	147
Blue sandy clay	9	156
Red clay, shaly	9	165
White sand, small amount of water	14	179
Red clay, shaly	11	190
Yellow sandy clay	4	194
White coarse sand, water bearing	16	210
Red clay, shaly	5	215
Yellow sandy clay	5	220
Gray sandy clay, lead color	9	229
Tough micaceous clay, resembling residual mica schist	5	234
Micaceous silt	11	245
Basement rocks:		
Soft gray decomposed crystalline rock	5	250
Hard crystalline rock	17	267

Mr. Wood states that two or three water-bearing beds were encountered at various depths in each of the wells Nos. 1 to 26 except No. 1, in which there was but one bed. The water was admitted to the casings by means of strainers inserted at the water-bearing beds, the length of the strainers being determined by the thickness of the beds. When first drilled, the water in each of the 26 wells rose to within 20 feet or less of the surface, and three of the wells, Nos. 17, 18, and 19, flowed about 10 gallons per minute each. The strainers, however, permitted the water from the lower beds to drain into the upper nonflowing beds and the flows ceased. In general the deeper the water-bearing bed the greater the yield.

FIGURE 4.—Sketch map showing distribution of test wells near Columbus.

During the progress of the work a test was made of the combined capacity of wells Nos. 1 to 28. Water was pumped by air lift for 144 consecutive hours at about 3,000,000 gallons per 24 hours, at which rate the static head was lowered to about 125 feet below the surface. Three-fifths of the water stipulated in the contract was thus produced.

Although the yield, as shown by the test, was less than that required, it was more than twice as great as that now consumed daily by the city, and if maintained continuously would supply the city's needs for many years to come. These wells, however, are only 3 miles south of the fall line, and the catchment area is therefore relatively small. It seems possible that the water table would be gradually lowered until eventually the reservoir would be exhausted.

The following is a mineral analysis of water from test well No. 35, collected March 27, 1911, and analyzed by Edgar Everhart. The sample probably consisted of a mixture of water from several beds between 100 and 232 feet, all of which belong to the Lower Cretaceous.

Analysis of water from test well No. 35 near Columbus.

	Parts per million.
Silica (SiO_2)	52
Iron (Fe)	1.0
Calcium (Ca)	37
Magnesium (Mg)	6.8
Sodium and potassium (Na+K)	47
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	88
Sulphate radicle (SO_4)	75
Nitrate radicle (NO_3)	.0
Chlorine (Cl)	38
Total dissolved solids	314

The water from the wells is said to have been used in some of the boilers at the plant for 18 months without forming any appreciable scale.

Had these test wells been located several miles farther south in southern Muscogee County or eastern Chattahoochee County, where the Lower Cretaceous deposits have increased to nearly double their thickness at the mouth of Bull Creek, the supply of water obtainable would have been much larger and there would probably have been no danger of exhausting the reservoir by heavy pumping.

So far as reported, no shallow wells are used for domestic purposes within the corporate limits of Columbus. On a thickly inhabited plain, such as that on which the business part of the city stands, water from shallow depths is peculiarly liable to contamination.

That a large supply of water may be obtained from shallow sources within the city limits is certain, as shown by the following data of wells at the plant of Golden's Foundry & Machine Co., furnished by I. E. Golden, secretary and treasurer:

The wells, five in number, are located on block No. 12, between Cemetery Street and Sixth Avenue and between Fifteenth Street and the Central of Georgia Railway. They are all dug and range in depth from 32 to 36 feet, reaching but not entering the crystalline basement rocks. The water comes from sand and gravel beneath beds of sand and clay at the base of the Pleistocene terrace deposits or in Lower Cretaceous deposits, a few feet of which may intervene between the basement rocks and the overlying terrace deposits. It stands 6 to 8 feet below the surface during wet seasons and at greater depths during dry seasons. The yield varies greatly with the seasons, but the minimum available from the five wells is 150 gallons per minute. The water is obtained by suction pumps.

PIERCE COUNTY.

GENERAL FEATURES.

Pierce County is in the southeastern part of the Coastal Plain of Georgia. Blackshear, the county seat, is on the Atlantic Coast Line Railroad, 87 miles southwest of Savannah. The area is 605 square miles and the population is 10,749 (census of 1910). Agriculture and the production of lumber and naval stores are the chief industries.

TOPOGRAPHY.

The county from a few miles southeast of the Atlantic Coast Line Railroad northwestward is a slightly undulating upland, 100 to 200 feet above sea level, which forms part of the physiographic division known as the Altamaha upland or long-leaf pine region. The remainder of the county, in the southeast and south, is a flat, poorly drained plain 60 to 100 feet above sea level, forming a part of the physiographic division known as the Okefenokee plain. Small cypress ponds and swampy saw-palmetto and gallberry flats are numerous.

GEOLOGY.

In the western part of the county the surface deposits consist of 100 feet or less of irregularly bedded sands and clays, in part water bearing, probably of Oligocene age. In the central and north-central parts of the county similar undifferentiated deposits of Miocene to Pleistocene age outcrop. (See geologic map, Pl. III.) The remainder of the county is covered by sands and clays of Pleistocene age, probably not exceeding 50 feet in thickness. The undifferentiated Oligocene to Pleistocene deposits and the known Pleistocene sands and clays are the source of the waters obtained in shallow wells.

The series of Tertiary deposits probably includes in descending order representatives of the Pliocene, Miocene, Oligocene, and Eocene. (See logs of wells at Offerman, pp. 357–358, at Doctortown, Wayne County, pp. 452–453, and at Waycross, Ware County, pp. 437–439.) The upper 420 or 450 feet of these deposits consists of sands and greenish or drab sandy clays, with subordinate layers of limestone, phosphatic sand, or sandy shell marl and gravel. There follows 255.5 feet of limestones interbedded with layers of sand and shell marl, which may represent in descending order the Alum Bluff, Chattahoochee, Vicksburg, and perhaps also the Jackson formation. (See log at Offerman, p. 358.) Nothing definite is known concerning the deposits below the limestone, but it is believed that they include in descending order older Eocene and Cretaceous strata, which at an unknown depth, perhaps 3,000 feet or more, rest upon a basement of ancient crystalline rocks.

The Tertiary deposits and probably also the Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Wells of the dug and driven types ranging in depth from 10 to 30 feet are the principal source of domestic water supply. Two artesian wells have been drilled at Offerman.

The springs of the county are small and unimportant as sources of supply.

Artesian water can be obtained anywhere in the county at depths of 100 to 1,500 feet or more. It is probable that the static head of deep wells located on the lowlands bordering Satilla and Little Ocmulgee rivers in the southern and eastern parts of the county will be high enough to produce flows at the surface.

LOCAL SUPPLIES.

Blackshear (population 1,235, census of 1910).—Blackshear, the county seat, installed a public water-supply system in 1913, obtaining water from an 8-inch well 825 feet deep. Information concerning the well and the waterworks plant has been furnished by the Hughes Specialty Well Drilling Co., of Charleston, S. C., and by the A. P. Brantley Co., of Blackshear. The following log, furnished by the first-named company, was prepared by J. R. Connelly, driller in charge:

Log of town well at Blackshear.

		Thickness.	Depth.
		Feet.	*Feet.*
Soft red clay		20	20
Soft white sand		10	30
Soft white clay		20	50
Soft white sand		10	60
Tough red clay		40	100
Soft blue marl		40	140
Alternate layers of soft blue marl and sand		30	170
Hard blue rock		10	180
Alternate layers of marl and hard blue rock		60	240
Tough blue marl		20	260
Hard light-gray rock		20	280
Alternate layers of light-blue shell rock and marl, water bearing		40	320
Hard light-blue flint, water bearing		10	330
Hard layer of shells		5	335
Hard flint		2	337
Soft blue marl		8	345
Hard shell rock		35	380
Dark-gray, hard, flinty shell rock		40	420
Shell rock, similar to the preceding but somewhat softer		20	440
Hard dark-gray shell rock	Contain water-bearing layers; the principal source of supply.	10	450
Soft light-gray shell rock		50	500
Hard dark-brown layer of shells		20	520
Hard flint		5	525
Medium-hard light-gray shell rock		25	550
Hard flint		20	570
Tough dark-brown layers of shells		255	825

The well probably completely penetrates the Oligocene (including in descending order the Alum Bluff, Chattahoochee, and Vicksburg formations), and enters the upper part of the underlying Eocene. Water-bearing beds were encountered between 300 and 330 feet and between 450 and 825 feet. Eight-inch casing was inserted to 450 feet only, so that all water-bearing beds between that depth and the bottom of the well are utilized. The elevation of the mouth of the well is about 10 feet above the ground level at the Atlantic Coast Line Railroad station or about 116 feet above sea level. The water rises to within 55 feet of the surface and is lifted to the surface by means of an air-lift pump. The well will yield 1,000 gallons per minute. The water is said to be somewhat hard and sulphurous. The well was drilled at a cost of $350.

The water is pumped from the well into a reservoir holding 100,000 gallons, and from the reservoir into an elevated tank having a like capacity. The latter furnishes a gravity pressure of 50 pounds per square inch and the possible direct pressure from the pumps is 100 pounds per square inch. The water is distributed through 5 miles of mains to 100 taps and 50 fire hydrants. The daily consumption is 10,000 gallons for domestic use and an equal amount for manufacturing.

Offerman (population 483, census of 1910).—At Offerman the domestic water supply is obtained from shallow dug and driven wells and from two deep wells owned by the Southern Pine Co. The following log of one of the deep wells, drilled in 1905, was published by Fuller and Sanford:[1]

[1] U. S. Geol. Survey Bull. 298, p. 201, 1906.

Log of the well of the Southern Pine Co., at Offerman.

[Samples received from the Hughes Specialty Well Drilling Co., Charleston, S. C.]

	Thickness.	Depth.
	Feet.	*Feet.*
Black soil, chiefly made land	1	1
Tough reddish and cream-colored sandy clay	39	40
Tough pink clayey sand	20	60
Loose coarse white gravel, water bearing; yields one-half gallon a minute for each foot head is depressed	10	70
Tough, sticky, cream-colored sandy clay	50	120
Loose fine grayish sand; no water	10	130
Not reported	50	180
Tough, sticky cream-colored marl, like pipe clay	60	240
Soft cream-colored sandy marl with hard layers	20	260
Dark blue sandy marl with hard layers	20	280
Loose coarse white sand	20	300
Soft blue-black and black sandy marl with hard layers	100	400
Loose fine brownish limy sand with hard layers	20	420
Tough, white limestone with hard layers	20	440
Loose fine white sand with hard layers	20	460
White limestone, water bearing	20	480
Loose fine gray sand, water bearing	10	490
Hard brown limestone and soft marl	10	500
Loose white sand containing glauconite; no water	18	518
Coarse gray sand with bits of soft limestone and shells; also black granules	(?)	532
No sample	8	540
Cream-colored limestone with siliceous gray limestone, chert nodules, and quartz grains.	10	550
Flinty gray limestone and yellow shell rock with chert nodules and quartz grains; two days drilling	5	555
Hard white sand (sample much like preceding); no water	5	560
Medium soft, cream-colored limestone (sample much like preceding)	10	570
Very hard flinty limestone (sample shows a little chert at 573–575 feet)	30	600
Very soft cream-colored limestone with plenty of water at 640 feet to bottom	75.5	675.5

Diameter of casing, 6 and 4½ inches; length, 635 feet. Water obtained from 640 to 675½ feet; rises within 33 feet of surface; is depressed about 25 feet by pumping 250 gallons a minute. Water slightly sulphureted. Temperature at well mouth, 76° F.

A partial set of borings from this well is on file in the office of the United States Geological Survey (wells Nos. 402 and 450). From borings taken between 450 and 575 feet specimens of fossil Bryozoa were obtained which R. S. Bassler says are related to the bryozoan fauna obtained from the Eocene limestones of upper Jackson age at Wilmington, N. C., and may indicate either a Jackson or a Vicksburg age for the containing strata.

Information regarding another well owned by the Southern Pine Co., drilled in 1898, is given by McCallie [1] as follows:

This well, owned by the Southern Pine Co., of Georgia, is located on the west side of the Atlantic Coast Line Railroad, almost a quarter of a mile north of the Atlanta, Birmingham & Atlantic Railroad junction. The well was put down in 1898 at a cost of $500. It is 8 inches in diameter and 125 feet deep. Originally the well was 515 feet deep but it subsequently filled with sand to 125 feet. The water, which is used for boiler purposes and for drinking, rises to within 108 feet of the surface. The maximum yield of the well is 40 gallons per minute. Rock is reported at 98 and 500 feet from the surface, the former bed extending to 108 feet, at which point water-bearing sand was struck.

The water of this well is probably derived from the Alum Bluff formation.

Ice.—An oil-prospecting well has been drilled near Ice post office, 4 miles northeast of Blackshear, by L. F. Hinson, but no detailed

[1] Georgia Geol. Survey Bull. 15, pp. 152–153, 1908.

information concerning it has been obtained. A sample from 400 feet is white limestone.

PULASKI COUNTY.[1]

GENERAL FEATURES.

Pulaski County is in the north-central part of the Coastal Plain of Georgia, the northern boundary of the county being about 30 miles south of Macon and the fall line. Its area is 463 square miles and its population is 22,835 (census of 1910). Agriculture is carried on extensively, and lumbering, though declining, is still an important industry.

TOPOGRAPHY.

In the northern part of the county the upland surface presents low rolling hills covered in part with a growth of oak and hickory. In the south the surface is more nearly level and, though now open, was once covered with a forest of long-leaf pine. Lime sinks occur throughout the county.

Ocmulgee River, the largest stream, has cut its valley scarcely more than 100 feet below the level of the upland. The river is bordered by two narrow Pleistocene plains, one lying 12 to 15 feet and the other 50 to 60 feet above low-water level.

GEOLOGY.

The Jackson formation, which consists of 150 feet or less of soft limestone interbedded with sands and clays, outcrops on Ocmulgee River along the northwestern boundary of the county and extends southward beneath the younger formations to, and probably far beyond, the southern boundary. The formation is water bearing.

The Vicksburg formation, which consists of 100 feet or less of limestone interbedded with sands and clays, overlies the Jackson formation and outcrops in the northern part of the county north of Hawkinsville and in the valleys of Ocmulgee River and Tuscawhachee Creek southward to the southern border of the county. The formation weathers to red, residual, argillaceous sands, which are the chief source of the water obtained in numerous shallow wells. The unweathered portion of the formation at greater depths is an important aquifer.

In the southeastern and southern parts of the county the Vicksburg formation is overlain by a thin covering, probably nowhere exceeding 100 feet, of ferruginous sands and sandy clays mapped with the undifferentiated Oligocene to Pleistocene, inclusive, which yield water to shallow wells.

[1] Under this heading is included a large area which has been organized as Bleckley County since this report was transmitted for publication. (See map, Pl. III, p. 52.)

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The Jackson formation is underlain by several hundred feet of undifferentiated sands, clays, and marls of Eocene age, in part water bearing. The Eocene deposits are in turn underlain by 1,000 feet or more of sands and clays of Cretaceous age, which rest upon a basement of ancient crystalline rocks. The Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Shallow dug wells are the main sources of domestic water supply and in general yield soft waters. Several artesian wells have been drilled at and near Hawkinsville and one deep well has been drilled at Cochran.

There are a few springs, but none of large size have been reported. Spring waters are used to a small extent for domestic supplies.

Artesian water can be obtained anywhere at depths of 100 to 1,000 feet or more.

On the Pleistocene terrace plains bordering Ocmulgee River the static head of the water will in many places be high enough to produce flows from wells 250 feet or more in depth.

LOCAL SUPPLIES.

Hawkinsville (population 3,420, census of 1910).—Hawkinsville is the county seat and the principal business town. The public water supply of approximately 100,000 gallons a day is derived from artesian wells.

The artesian wells in the vicinity of Hawkinsville range in depth from 175 to 500 feet and furnish an abundance of water which, though potable, is so hard that surface waters are preferred in laundries and in boilers. According to McCallie [1] one water-bearing stratum, at 265 feet, yields water which flows at the surface and another, at 490 feet, water that rises 12 feet above the surface. The following log of one of the wells is given by McCallie:

Log of well at Hawkinsville.

[Authority, Mr. Dearing, well contractor.]

	Thickness.	Depth.
	Feet.	*Feet.*
Red and yellow clays	40	40
Limestone with layers of blue clay	140	180
White limestone and clay	40	220
Blue clay	40	260
Coarse water-bearing sand, containing sharks' teeth	100	360
Limestone interstratified with clay; stopped on coarse water-bearing sand	130	490

[1] Georgia Geol. Survey Bull. 15, pp. 153, 154, 1908.

The following is an analysis of water from the 490-foot stratum, Edgar Everhart,[1] analyst:

Analysis of water from 490-foot bed at Hawkinsville.

	Parts per million.
Silica (SiO_2)	31
Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$)	5.3
Calcium (Ca)	62
Magnesium (Mg)	2.2
Sodium (Na)	16
Potassium (K)	3.6
Bicarbonate radicle (HCO_3)	200
Sulphate radicle (SO_4)	8.5
Chlorine (Cl)	18
Total dissolved solids	249
Free carbon dioxide (CO_2)	.0

The water-bearing stratum at 490 feet is either in the lower part of the Eocene or in the upper part of the Cretaceous deposits.

Cochran (population 1,638, census of 1910).—Cochran owns a deep well which furnishes water for domestic use to a part of the inhabitants. The well is reported to be 365 feet deep and the water rises to within 85 feet of the surface. The difference between the static head of this well and of the wells at Hawkinsville is due to the difference in elevation of the two places, Cochran being 341 feet and Hawkinsville only 235 feet above sea level.

TABLE 67.—*Wells in Pulaski County.*

No.	Location.	Owner.	Authority.	Date completed.	Approximate elevation above sea level.
					Feet.
1	Cochran	Town	S. W. McCallie[1]	1895	341
2	Hawkinsville	do	do		235
3	do	do	H. Vining	1905	

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	365	6	350		−85				Hard, sulphurous.
2	490		490	265	+12		320	Flows	See analysis above.
3	312	8				302		do	

[1] Georgia Geol. Survey Bull. 15, pp. 153–155, 1908.

TABLE 67.—*Wells in Pulaski County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Eocene	Sand?	
2	Municipal supply	Eocene or Cretaceous.	Sand	The city owns several deep wells. See log, p. 360.
3	do	Eocene	do	

QUITMAN COUNTY.

GENERAL FEATURES.

Quitman County is in the west-central part of the Coastal Plain of Georgia. Its area is 144 square miles and its population 4,594 (census of 1910). Agriculture is the chief industry.

TOPOGRAPHY.

The county lies within the physiographic division of the Coastal Plain known as the fall-line hills. The surface was once an upland plain but has been subsequently dissected by stream erosion and except in small areas near Chattahoochee River is now hilly. Two terrace plains, the limits of which have not been determined in detail, occupy a narrow area bordering the river. The lowest (Satilla plain) lies 40 to 50 feet above low-water level of the river and probably nowhere exceeds 2 miles in width; the higher (Okefenokee plain) is narrower and lies 110 to 120 feet above the same datum.

The county is drained by Chattahoochee River, chiefly through its tributaries, Pataula, Wellono, and several smaller creeks. The maximum surface relief of the county is probably between 300 and 400 feet.

GEOLOGY.

The Ripley formation of the Upper Cretaceous is the only pre-Tertiary formation outcropping in this county. The formation appears in a belt several miles wide bordering Chattahoochee River. It is underlain by buried representatives of the Eutaw formation of the Upper Cretaceous, and the latter is probably underlain by still more deeply buried Lower Cretaceous deposits. No wells of sufficient depth to determine the character and thickness of the several formations mentioned have been drilled in the county. At an unknown depth beneath the surface, probably 1,500 to 2,000 feet or more, the Cretaceous deposits rest upon crystalline basement rocks. The Ripley formation is unconformably overlain by Eocene strata which form the surface materials over the greater part of the county east of the Cretaceous belt.

The Ripley formation as exposed in the river bluffs consists chiefly of massive, compact, more or less calcareous and glauconitic marine sands, clays, and marls, with indurated layers at vertical intervals of a few feet to 10 feet or more; it contains, however, subordinate lenses and layers of loose, irregularly bedded sands and clays. The total thickness of the formation in the river section in Georgia is estimated to be about 950 feet. In the northern part of the county the upper beds of the formation merge horizontally into the irregularly bedded, shallow-water sands and clays of the Providence sand member, which probably attains a maximum thickness of 125 feet.

The Ripley formation is unconformably overlain by the Midway formation, an Eocene terrane composed of sands, clays, marls, and limestones. The Midway strata form the surface materials over the greater part of the county, but the Wilcox formation, also of Eocene age, which overlies the Midway formation, appears in a relatively small area in the extreme southeastern part of the county. (See Pl. III, p. 52.)

Pleistocene terrace deposits, coextensive with the terrace plains, rest unconformably upon Cretaceous and Tertiary strata in small areas bordering Chattahoochee River.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The chief sources of domestic water are wells of shallow or moderate depth, mostly of the dug type, and small springs. On the river terraces the depth of the wells does not as a rule exceed 40 feet, the source being the sands and gravels at the base of the terrace deposits. In the hilly upland to the east, which includes the greater part of the area, wells 40 to 100 feet or more in depth tap water-bearing strata in the Cretaceous and Tertiary formations.

Small creeks and spring branches afford an ample supply of excellent water for domestic animals and for steam production.

In the west moderate quantities of rather highly mineralized waters may be obtained from water-bearing sands in the Ripley and Eutaw formations at depths of 100 to 1,000 feet or more. Throughout the remainder of the county the same beds may be reached by drilling through the overlying Eocene strata, but they lie at increasingly greater depths to the southeast away from the belt of outcrop of the Cretaceous strata.

In a small area the Providence sand member of the Ripley formation is an especially promising aquifer, for it is composed predominantly of coarse, irregularly bedded sands.

The porous sands of the Midway formation, which overlie the Ripley formation, carry waters in moderate quantities.

Flows can be expected only from wells on the lowest river terrace at elevations less than 50 feet above low-water level.

LOCAL SUPPLIES.

Well of J. F. Hogan.—J. F. Hogan has furnished the following data concerning a well located on his property, 11 miles northeast of Georgetown.

The well is situated on a hill and is of the driven type. The depth is 150 feet and the diameter is 2 inches. Two-inch casing extends to the bottom. The water, which is derived from sand, rises 5 feet in the casing and is lifted to the surface by a force pump. The water is soft and is used for general domestic purposes. The cost of the well was $150. Except for 20 feet of clay in the upper part, the section was principally sand. The clay should probably be referred to the Midway formation of the Eocene, and the remainder of the section to the Providence sand member of the Ripley formation.

Eufaula, Ala.—Several deep wells have been drilled at Eufaula, Barbour County, Ala., data concerning which have been published by E. A. Smith,[1] State geologist. The underground conditions are essentially the same as those immediately to the east in Quitman County.

At Eufaula the altitude of the well from which the city supply is derived is 110 feet below that of the railroad track at the depot, or 90 feet above mean tide; that of the Oil & Gin Co.'s well is about the same as that of the depot—200 feet above tide; and that of the well at Moulthrop's brickyard is probably intermediate between the two. At the two lower wells the water overflows, but not at the other. In all these the supply seems to be inadequate.

City Water Co.'s well, Eufaula, under the bluff on the west bank of Chattahoochee River, 110 feet below the city; casing, 4-inch; flow, 5¾ gallons per minute; hydraulic ram used; temperature, 68°. Boring is in marl to water-bearing sands at 400 feet; several layers of soft rock; hard rock below the water-bearing sand.

Eufaula Oil & Gin Co.'s well, Eufaula; bored in 1895; depth 950 feet; water at first stood at −26 feet, now stands at −50 feet; cased at 300 feet, 4-inch and 6-inch; supply insufficient; well abandoned.

[*Record of Eufaula Oil & Gin Co.'s well, Eufaula, Ala.*]

	Feet.
Top soil and sand	0– 30
Marl	30–380
Soft sandstone	380–381
Cavity, with a little water	381–389
Marl, water below in very fine sand	389–950

Well at Moulthrop's brickyard, 1 mile southeast of Eufaula; bored in April, 1900, by Eugene Thompson; depth, 350 feet; casing 20 feet, 4-inch; flow, 5 gallons per minute. Record: Top soil, 0–20; marl water, 20–350. The water-bearing bed in this well is a sharp gray sand of fine grain, used by engineers for grinding valves. The boring went 15 feet deeper than this sand and struck a hard rock which was not pierced. The marl contains a great many shells, and in it at intervals of about 30 feet occur indurated crusts.

[1] The underground water resources of Alabama: Alabama Geol. Survey, pp. 240-241, 1907.

The following analysis of water from the last-described well was made at the Pratt Laboratory, Atlanta, Ga.;[1] the source of the water is the Ripley formation.

Analysis of water from well at Moulthrop's brickyard, 1 mile southeast of Eufaula, Barbour County, Ala.

	Parts per million.
Silica (SiO_2)	16
Iron and aluminum (Fe+Al)	1.9
Calcium (Ca)	3.5
Magnesium (Mg)	.8
Sodium (Na)	137
Potassium (K)	3.0
Bicarbonate radicle (HCO_3)	351
Sulphate radicle (SO_4)	5.2
Chlorine (Cl)	14
Organic and volatile matter	33
Total dissolved solids	387

RANDOLPH COUNTY.

GENERAL FEATURES.

Randolph County is in the southwestern part of the Coastal Plain of Georgia. Cuthbert, the county seat, is 118 miles by rail southwest of Macon and 45 miles south of Columbus. The area of the county is 412 square miles and the population is 18,841 (census of 1910). Agriculture is the principal industry, but there are a few small manufacturing plants at Cuthbert and at Shellman.

TOPOGRAPHY.

The northern part of the county is hilly and broken, the estimated altitude of the general upland surface being 350 to 500 feet above sea level. The creeks and branches have cut valleys in soft sands and clays, 100 to 150 feet beneath the upland level. The upland declines slightly southward and becomes less broken until south of Cuthbert its surface is only slightly rolling. The county is on the divide between the Chattahoochee and Flint drainage systems and the streams are small and their waters clear The western part of the county is drained by tributary creeks of Chattahoochee River, and the eastern part by Ichawaynochaway Creek and its tributaries Cuthbert, on the summit of the divide, is 469 feet above sea level.

GEOLOGY.

Strata of Eocene age form the surface materials throughout the greater part of the county and consist of several hundred feet of sands, clays, marls, and limestones containing important water-

[1] Smith, E. A., op. cit., p. 241.

bearing beds. Although not accurately discriminated within the county it is believed that the Eocene deposits represent in ascending order the Midway formation, the Wilcox formation, and the Claiborne group. (See Pl. III, p. 52.) The Midway formation outcrops in a relatively small area in the extreme northwest, where it has been recognized on the evidence of fossils, and dips slightly to the southeast. The Wilcox formation, which overlies the Midway, outcrops in a belt several miles wide, extending northeast and southwest through the northwestern part of the county. The Claiborne group rests upon the Wilcox formation and outcrops in an irregular area extending in a general northeast and southwest direction through the county, with important branches extending down the valleys of Ichawaynochaway and Pachilla creeks to the southern boundary.

In the interstream areas in the southern part of the county the Claiborne group is overlain by the Vicksburg formation (Oligocene), which consists of probably less than 100 feet of residual sands with masses of flint and some beds of unweathered limestones.

The Eocene deposits are underlain by 2,000 feet or more of sands, clays, and marls of Cretaceous age, which do not come to the surface within the county, and which rest upon a deeply buried surface of ancient crystalline rocks. They contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug and bored wells 30 to 100 feet deep are the principal sources of domestic water supply. Most of them yield soft, wholesome waters, but a few enter calcareous strata and yield hard waters. Bored wells 75 to 100 feet deep are practicable over most of the county and when properly cased are preferable to the dug wells, for they are less liable to be polluted.

Springs are common in the northern part of the county and are used to some extent for domestic water supply on farms. Most of them issue from sands in the Midway and Wilcox formations, but a few emerge from cavernous limestones of the same formations.

Artesian water can be obtained anywhere in the county at depths of 100 to 1,000 feet or more. On the lowlands bordering the creeks in the southeast the chances for obtaining flows are considered good.

In the northern part of the county the most abundant supplies can probably be obtained from the Cretaceous deposits, the top of which is estimated to be 300 to 500 feet below the surface. The full thickness of the Cretaceous is thought to be 2,000 feet or more, but water-bearing beds are apt to be encountered at less than 1,000 feet.

In the southern part of the county, south of Cuthbert, large supplies can probably be obtained from the Claiborne group or from the underlying Wilcox and Midway formations at depths ranging from 200 to 700 feet.

LOCAL SUPPLIES.

Cuthbert (population 3,210, census of 1910).—Cuthbert does not own a public water-supply system, and the domestic water supply is obtained chiefly from shallow wells owned by individuals. It is believed that artesian waters could be obtained in large quantities, and such waters would probably prove more satisfactory for general purposes than those from other sources.

The following note on an old well at Cuthbert is given by Spencer:[1]

This well was sunk to a depth of 1,000 feet but the record was not kept. From a point between 340 and 400 feet water rose to within 30 feet of the surface, and at 550 feet the water rose to within 70 feet of the surface.

A well drilled in 1910 by the Cuthbert Ice Co. near the Central of Georgia Railway station is 435 feet deep. The water, which probably comes from the Midway formation, rises to within 33 feet of the surface. The yield by pumping is 75 gallons per minute. The water is reported to be soft and is used for the manufacture of ice and for drinking purposes.

Shellman (population 985, census of 1910).—At Shellman the principal source of water supply is an artesian well (No. 3, Table 68) owned by the town. Several shallow wells 35 to 65 feet deep are owned by individuals. McCallie[2] gives the following information regarding the town well:

The deep well at Shellman, which supplies the town with water, was completed in 1902. It is 6 inches in diameter and 410 feet deep. The only water-bearing stratum reported occurs near the bottom of the well. The water rises to within 70 feet of the surface. Mr. J. E. Cole, the well contractor, has kindly furnished the following record:

[*Log of town well at Shellman (No. 3, Table 68).*]

	Feet.
Red clay	0– 18
Quicksand	18–148
Blue marl	148–300
Very hard limestone	300–400
Water-bearing formation	400–410

From specimens furnished by Mr. Cole the writer has made the following additional notes:

	Feet.
Green sandy, glauconitic marl	250
The same as above but with more sand	350
Quartzose and calcareous sand	400

[1] Spencer, J. W., Georgia Geol. Survey First Rept. Progress, p. 79, 1891.
[2] Georgia Geol. Survey Bull. 15, pp. 155, 156, 1908.

The following is an analysis of a sample of water from the town well at Shellman, Edgar Everhart, analyst. The water is probably derived from the Midway formation:

Analysis of water from the town well at Shellman (No. 3, Table 68).

	Parts per million.
Silica (SiO_2)	27
Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$)	4.6
Calcium (Ca)	47
Magnesium (Mg)	1.4
Sodium (Na)	4.8
Potassium (K)	1.9
Bicarbonate radicle (HCO_3)	134
Sulphate radicle (SO_4)	12
Chlorine (Cl)	5.4
Total dissolved solids	174

TABLE 68.—*Wells in Randolph County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Cuthbert	Town		J. W. Spencer[a]		446
2	do	Cuthbert Ice Co	B. F. Boland, Havana, Fla.	W. J. McLaren	1910	446
3	Shellman	Town	J. E. Cole	S. W. McCallie[b]	1902	379

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	1,000	4	340–400	550	30, 70				
2	435	4½	435	60, 130, 300	33		75	Steam engine, deep-well pump.	Soft.
3	410	6	400–410		70				See analysis above.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Abandoned	Midway formation?		
2	Manufacture of ice and domestic.	do	Porous gray rock	120 feet of 6-inch and 110 of 4½-inch casing. Cost of well, $800; of pump, $100.
3	Domestic	do	Sand	See log, p. 367.

[a] Georgia Geol. Survey First Rept. Progress, p. 79, 1891.
[b] Georgia Geol. Survey Bull. 15, pp. 155, 156, 1908.

RICHMOND COUNTY.

GENERAL FEATURES.

Richmond County is in the east-central part of Georgia. Its area is 319 square miles and its population (census of 1910) is 58,886. In Augusta, the population of which is 41,040, the chief industries are the manufacture of cotton goods, the extraction of cottonseed oil, and the manufacture of carriages, wagons, and lumber products. Outside of Augusta the chief industry is agriculture.

TOPOGRAPHY.

The county is included in the physiographic division of the Coastal Plain known as the fall-line hills. Savannah River forms its eastern boundary and McBean Creek its southern boundary. The area, at one time an upland plain, has been dissected and rendered hilly, with a probable maximum relief of 400 to 450 feet. The streams which effected the dissection of the upland plain are Savannah River and its tributaries, McBean, Spirit, and Butlers creeks. In a strip several miles wide bordering Savannah River and extending from Augusta southward two terraces were cut during Pleistocene time. The lower, the Satilla plain, lies 20 to 30 feet above low-water level of the river, and the higher, the Okefenokee plain, lies 75 to 100 feet above the same datum plane. The plains, particularly the lower one, are still well preserved in places. Augusta is built chiefly upon these two plains.

GEOLOGY.

Deposits of the Coastal Plain outcrop throughout the county except in a small area in the extreme north, where crystalline rocks of probable pre-Cambrian age appear at the surface. The upper surface of the crystalline rocks dips southward beneath the deposits of the Coastal Plain and forms the basement upon which the latter rest. These basement rocks were encountered in a well at Gracewood, 7 miles south of Augusta, at a depth of 410 feet. (See log, p. 373.)

Lower Cretaceous deposits outcrop in a belt several miles wide, extending from Augusta and south of Augusta westward to the county line. They rest upon the southward-sloping surface of the basement rocks and consist of 300 feet or more of irregularly bedded arkosic sands with interbedded lenses of light-colored clays of greater or less purity. They extend southward beneath overlapping strata belonging to the Claiborne group of the Eocene.

The Claiborne beds, with local exceptions, are the surface materials over the southern half of the county. They also cap the ridge between Butlers and Spirit creeks and extend northwestward along the ridge to Grovetown in Columbia County. The Claiborne materials consist of calcareous and glauconitic sands, red and varicolored sands, clays in the nature of fuller's earth, shell marls, and sandy limestones. (See Pl. III, p. 52.)

In an area several miles wide, bordering Savannah River, the Lower Cretaceous and Eocene deposits are overlain by relatively thin terrace deposits of Pleistocene age. The Lower Cretaceous deposits carry large quantities of water and the overlying Eocene deposits are in less degree water bearing.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Throughout the rural districts domestic supplies are obtained chiefly from dug wells 25 to 130 feet in depth, which tap water-bearing beds in the Lower Cretaceous deposits, and from small springs. On the Pleistocene terrace plains bordering Savannah River, wells 20 to 40 feet in depth penetrate the water-bearing basal sands and gravels of the terrace deposits. In the hilly areas west of the river valley it is necessary in most places to sink the wells to greater depths, the water-bearing beds drawn upon being in the Cretaceous and Eocene deposits. Detailed information concerning several wells of the dug type, which may be regarded as typical, is given in Table 69 (wells 2 to 6 and 8).

The water from both wells and springs is of good quality for domestic purposes except where contaminated by near-by organic matter.

With local exceptions the numerous creeks and branch streams afford excellent water for domestic animals and for steam production.

The Lower Cretaceous deposits, which underlie all the county except a relatively small area in the north, are of favorable physical texture and composition for the reception and retention of large quantities of water of excellent quality. Along the northern border of the Coastal Plain, from Augusta westward to the western boundary of the county, where the featheredge of the formation rests against the crystalline rocks, the Lower Cretaceous deposits are too thin and lie too high on the stream divides to afford more than moderate amounts of water. The thickness rapidly increases to the southward, however, and the buried deposits throughout the southern two-thirds of the county are believed to contain an abundance of water at depths of 200 to 800 feet.

The Eocene strata, which rest upon the Lower Cretaceous deposits over much of the area and which vary in thickness from a few feet in the central part of the county to 300 feet in the extreme south, carry moderate amounts of potable water.

No flowing wells have been reported, but the conditions are probably favorable for obtaining flows in the valley of Savannah River, south of Augusta, at elevations less than 50 feet above low-water level, and perhaps also at low levels in the valleys of Butlers, Spirit, and McBean creeks.

As shown by the records of two deep wells (see pp. 371–372) the prospects for obtaining water in fairly large quantities from the crystalline rocks which underlie the deposits of the Coastal Plain are fairly good in the vicinity of Augusta.

LOCAL SUPPLIES.

Augusta (population 41,040, census of 1910).—Information concerning the water plant which supplies the city of Augusta has been furnished by Mayor Thomas Barrett, jr.; by Nisbet Wingfield, city engineer and commissioner of public works; and by S. B. Vaughn, postmaster.

The plant is under municipal ownership. The water is pumped from Savannah River above Augusta to a reservoir having a capacity of 50,000,000 gallons, located on an eminence north of the city. Two pumps are used, each having a capacity of 6,000,000 gallons daily. From the main reservoir the water passes by gravity into 14 mechanical filters of the gravity type, each with a capacity of 500,000 gallons daily, from which it flows to a clear-water basin and is distributed to the city by gravity under a pressure of 70 pounds. The total length of the distributing mains is 66.94 miles. There are 4,246 taps for domestic purposes, 130 for manufacturing purposes, and 788 fire hydrants. The total amount of water used daily for all purposes is 5,800,000 gallons. The water supply is satisfactory. An auxiliary steam pump with a daily capacity of 6,000,000 gallons is now being installed at the pumping station.

A well (No. 1, Table 69) drilled at the plant of the Georgia Chemical Works, 1½ miles south of the post office, is 970 feet deep and is reported to have entered rock, probably crystalline rock of pre-Cambrian age, at a depth of 80 feet. The 80 feet of materials above the rock are sediments of the Coastal Plain, of which the first 20 or 25 feet probably are Pleistocene terrace deposits and the remainder Lower Cretaceous sands and clays. No water is reported from the Cretaceous beds; if water-bearing horizons were penetrated they

were cased off, for 8-inch casing was extended to the rock. The water is not good for steam production because of the hard scale it deposits.

According to McCallie [1] water was encountered in this well, probably in crevices in the crystalline rocks, between 150 and 190 feet (static head 90 feet below the surface), between 200 and 300 feet (static head 80 feet below the surface), between 500 and 700 feet (static head 75 feet below the surface), and between 800 and 900 feet (static head 45 feet below the surface).

Somerville (population 4,361, census of 1910).—A well 814 feet deep at the arsenal at Somerville, a suburb of Augusta, has been described by Capt. D. M. Taylor,[2] United States Army, as follows:

> Three water-bearing strata were struck in the well at 500, 600, and 700 feet, respectively. As much as 1,080 gallons per hour have been pumped from the well without perceptibly lowering the static head. The water is hard and slightly chalybeate. The first 85 feet passed through consisted of sand, red clay, and gravel. Hard chloritic slate was reached at 280 feet, which was followed by a similar rock, with occasional thin layers of quartz, to 700 feet. The rock varies in hardness, occasionally being comparatively soft, but generally very hard and tough, the softer rock being met with immediately above the watercourses and including them, and the hardest immediately below these watercourses. Near the bottom of the well was found a greenish quartz rock.

Another well at the arsenal is described by Capt. Taylor [3] as follows:

> I have one at the arsenal from which the main supply of water is now obtained. It is about 160 feet deep and 5 or 6 feet in diameter, and the water stands in it at a constant depth of between 9½ and 11 feet, not varying at all from local rains or droughts. It is usually pumped dry every day and fills again for the next day's pumping. This water I consider much better than that from the artesian well.

Gracewood.—A well (No. 7, Table 69) was drilled in 1912 at the Augusta Orphan Asylum, Gracewood, Ga., 7 miles south of Augusta. The following log has been furnished by the Hughes Specialty Well Drilling Co., of Charleston, S. C.:

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[1] Georgia Geol. Survey Bull. 15, p. 157, 1908.
[2] Idem, pp. 157–158.
[3] Idem, p. 158.

Log of well at Augusta Orphan Asylum, Gracewood (No. 7, Table 69).

[Authorities, S. L. Hughes and J. R. Connelly, drillers.]

	Thickness.	Depth.
	Feet.	*Feet.*
Loose coarse reddish sand	25	25
White and yellow, very sticky clay or kaolin	15	40
Pink sticky clay or kaolin	15	55
Red sticky clay or kaolin	15	70
Lighter red sticky clay or kaolin	60	130
Soft white sand	10	140
Soft white clay and sand	40	180
Soft red mud	20	200
Soft white clay and sand	15	215
Soft white sand	20	235
Soft white gravel	30	265
Soft white sand and clay mixed	10	275
Sticky red mud	10	285
Soft white sand which caves readily	20	305
Alternate layers of soft, sticky, white clay and sand	10	315
Alternate layers of soft blue, white, and yellow sand and clay	25	340
Soft white sand, water bearing	8	348
Tough blue marl [clay?]	22	370
Tough blue marl and shale	20	390
Hard blue marl and shale	20	410
Hard bluish gray rock, the crystalline basement rock; some water obtained in crevices	91.5	501.5

The water is said to come in part from depths of 348 to 370 feet, where, according to the log, the materials are tough blue marl (clay ?), and it is probable that the water comes from the soft white sand which immediately overlies the clay. The age of this sand is Lower Cretaceous. The crystalline basement rocks, described as granite, were struck in the well at a depth of 410 feet and were penetrated to a depth of 501.5; some water was obtained from crevices in the granite.

Windsor Spring.—Windsor Spring, owned by W. H. T. Walker, is 9 miles south of Augusta. According to the owner the spring emerges on a hill slope from rock probably belonging to the Claiborne group, at the rate of 15 gallons per minute. The water is bottled and sold. The following analysis was made by H. C. White in June, 1909:

Analysis of water from Windsor Spring, 9 miles south of Augusta.

	Parts per million.
Silica (SiO_2)	3.9
Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$)	.2
Calcium (Ca)	3.4
Magnesium (Mg)	.6
Sodium (Na)	.8
Potassium (K)	.4
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	12
Sulphate radicle (SO_4)	1.6
Chlorine (Cl)	1.2
Organic and volatile matter	2.1
Total dissolved solids	20

TABLE 69.—*Wells in Richmond County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Augusta, 1½ miles south of post-office building.	Georgia Chemical Works.	.....	A. Thomas, superintendent Georgia Chemical Works.	1885	130
2	Augusta, 4½ miles west of.	P. C. Bohler.....	.....	Owner.....	.....	(a)
3	Belair, 2½ miles south of.	R. O. Lombard	John Raborn, Hephzibah, Ga.	.....do.....	1900	500±
4	Blythe, ½ mile east of.	E. L. Atkinson.....	.....	.....do.....	1905	(b)
5	Debruce, 2 miles north of.	R. T. Ulm.....	.....	.....do.....	1904	(c)
6	.....do.....	.....do.....	.....	.....do.....	1904	(c)
7	Gracewood.....	Augusta Orphan Asylum.	Hughes Specialty Well Drilling Co., Charleston, S. C. (S. L. Hughes and J. R. Connelly, drillers in charge).	Hughes Specialty Well Drilling Co., Charleston, S. C., and H. H. Alexander, Augusta, Ga.	1912	(d)
8	Hephzibah, 1½ miles east of.	P. B. Carpenter.....	.....	Owner	.....	.....
9	Somerville.....	U. S. Government...	.....	Capt. D. M. Taylor, U. S. Army.e	.....	.....
10	.....do.....	.....do.....	.....	.....do.....	.....	.....

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute by pumping.	How obtained.	Quality.
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*			
1	970	8	.....	.....	17½	40 gallons	Electrically driven deep-well pump.	Soft.
2	34	48	34	20	30–32	Small.....	Bucket and rope..	Do.
3	132	36	130	42	120–127	.....do.....	.....do.....	Do.
4	100	36	100	50	97	.....do.....	.....do.....	Do.
5	144	48	140	80	140	.....do.....	.....	Do.
6	84	48	80	.....	.....	.....do.....	Hand pump.....	Do.
7	501.5	6	348–350	501.5	130	200 gallons.....	Deep-well pump; gasoline engine.	Do.
8	56	42	56	.....	.....	Small	Bucket and rope..	Do.
9	814	8	500 600 700	.....	.....	18 gallons	Force pump.....	Hard and slightly ferruginous.
10	160	60	.....	.....	9½	.....	.....do.....	

a On hill.
b Mouth of well about level with track of Augusta Southern R. R.
c On high hill.
d Elevation about 200 feet above low-water level in Savannah River.
e Georgia Geol. Survey Bull. 15, pp. 157, 158, 1908.

TABLE 69.—*Wells in Richmond County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Condensing	Pre-Cambrian	Crevices in crystalline rocks.	Drilled; 8-inch casing to 80 feet.
2	Domestic	Lower Cretaceous.	Sand	Dug; partly cased. Cost of well, $25.
3	do	do	Coarse sand	Dug; partly cased. Cost of well, $50.
4	do	do	Sand	Dug; partly cased.
5	Abandoned	do	do	Dug; abandoned on account of caving sand. Cost of well, $140.
6	Domestic	do	do	Dug. Located 50 feet from preceding well.
7	do	do	White sand?	6-inch casing to 348 feet; the water probably comes from the white sand between the depths 340 and 348 feet. See log, p. 373.
8	do	do	Sand	Dug. Cost of well, $28.
9		Pre-Cambrian	Crevices in crystalline rocks.	
10	Domestic	Pre-Cambrian?	do	Main supply at arsenal.

SCHLEY COUNTY.

GENERAL FEATURES.

Schley County is in the northwestern part of the Coastal Plain of Georgia. Its area is 154 square miles and its population 5,213 (census of 1910). Agriculture is the chief industry.

TOPOGRAPHY.

The surface is hilly, forming part of an upland plain that has been dissected by Cedar and Bucks creeks and by the headwater streams of Muckalee Creek. The maximum surface relief probably does not exceed 200 feet.

GEOLOGY.

Upper Cretaceous strata belonging to the Ripley formation outcrop over the northern half of the county, and Eocene strata appear in the remainder. The Cusseta sand member of the Ripley formation, which consists of irregularly bedded sands and clays of shallow-water origin, appears in a small area in the extreme north. The Cusseta sand is overlain conformably by typical marine beds of the Ripley formation, which consist of several hundred feet of compact, massive, more or less calcareous and glauconitic marine sands and clays. The typical marine beds are overlain by the Providence sand member of the Ripley formation, which consists of approximately 150 feet of irregularly bedded sands and clays of shallow-water origin. The Ripley formation is overlain unconformably by Eocene deposits which belong chiefly to the Midway formation and which form the surface materials over the southern half of the county. The Midway formation is composed of sands and clays reaching a thickness of several hundred feet. (See Pl. III, p. 52.)

The Cusseta and Providence sand members of the Ripley formation are of the proper texture and composition for the reception and retention of large quantities of potable water. The typical marine beds of the Ripley formation and the sands and clays of the Midway formation of the Eocene also carry water but probably in much less quantity.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug wells 20 to 100 feet deep and small springs furnish an abundance of excellent water for all ordinary domestic purposes. Small creeks and branches furnish inexhaustible supplies for stock and for steam production.

Over the northern half of the county water of good quality should be obtained from the Cusseta sand member of the Ripley formation. In the extreme north these water-bearing beds should be reached at depths between 100 and 400 feet. To the south the beds descend until in the valley of Bucks Creek they probably lie 300 to 500 feet beneath the surface. In the southern half of the county conditions are favorable for obtaining water from the Providence sand member of the Ripley formation by drilling through the overlying Eocene beds. At Ellaville the water-bearing beds of the Providence member probably lie 100 to 250 feet below the surface.

Over the greater part of the county it is necessary to employ force pumps to lift the water to the surface, although small flows can probably be obtained on the lowest levels of the valley of Bucks Creek.

In the southern part of the county the sands and clays of the Midway formation of the Eocene at 100 to 400 feet should yield moderate amounts of potable water.

LOCAL SUPPLIES.

Ellaville (population 672, census of 1910).—The town of Ellaville owns a public water-supply system, the data concerning which have been furnished by Mr. E. L. Bridges, of Ellaville.

The source of the water is a well 600 feet deep, drilled in 1910 at a cost of $2,000 for the well and $1,600 for the machinery. The water is lifted to the surface by means of an air-lift pump operated by a gasoline engine. The smallest diameter of the well is 4 inches, and the yield is said to be 50 gallons per minute. The water is derived from a bed of sand, probably belonging to the Ripley formation. A sample collected January 24, 1913, was analyzed by Edgar Everhart as follows:

Analysis of water from 600-foot town well at Ellaville.

	Parts per million.
Silica (SiO_2)	23
Iron (Fe)	5
Calcium (Ca)	17

Analysis of water from 600-foot town well at Ellaville—Continued.

	Parts per million.
Magnesium (Mg)	4
Sodium and potassium (Na+K)	9
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	25
Sulphate radicle (SO_4)	48
Nitrate radicle (NO_3)	Trace.
Chlorine (Cl)	4
Total dissolved solids	92

SCREVEN COUNTY.

GENERAL FEATURES.

Screven County is in the northeastern part of the Coastal Plain of Georgia and borders South Carolina. Savannah River forms its eastern and Ogeechee River its western boundary. Its area is 794 square miles and its population (census of 1910) is 20,202. Agriculture and the production of lumber and naval stores are the principal industries.

TOPOGRAPHY.

The northern part of the county is undulating to hilly and the southern part is more nearly level. There are several lime sinks and lime-sink ponds in the northeast, where the limestones of the Chattahoochee and Vicksburg formations lie close beneath the surface. In the south cypress ponds and bays are common and the small creeks and branches spread out through broad swamps. The upland between the Savannah and Ogeechee river basins slopes from about 250 feet above sea level in the north to about 150 feet above sea level in the south. Savannah and Ogeechee rivers are each bordered by swamps lying 10 to 20 feet above low-water level and by a narrow Pleistocene terrace plain lying about 40 feet above the same datum plane. The elevation of the low-water level of Savannah River in the extreme north is approximately 70 feet and in the extreme southeast approximately 25 feet above sea level. The elevation above sea level of the Savannah River swamp is about 90 feet in the extreme north and about 40 feet in the extreme southeast.

GEOLOGY.

The Vicksburg formation of the Oligocene, which consists of perhaps 100 to 200 feet of water-bearing limestones, outcrops in the valleys of Savannah River and Briar and Beaver Dam creeks in the northern part of the county. It dips southward and probably underlies the entire county beneath younger formations.

The Vicksburg formation is overlain by the Chattahoochee formation, which consists of probably less than 100 feet of water-bearing limestones and which outcrops in the valley of Briar Creek.

The Alum Bluff formation, which consists of 100 feet or more of laminated sandy clays and sands, overlies the Chattahoochee formation. It outcrops in the valleys of Savannah River and Buck Creek in the east and on Ogeechee and Little Ogeechee rivers in the west; the deposits carry water-bearing beds.

In the northern part of the county the Alum Bluff formation is overlain by coarse to fine or even pebbly, irregularly bedded sands and bluish sandy clays that are probably at least in part of upper Oligocene age.

In the southeastern part of the county the Alum Bluff formation is overlain by 50 feet or less of Miocene sands, sandy clays, and shell marls which outcrop in the bluffs of Savannah River, and which represent in ascending order the Marks Head marl and the Duplin marl.

Overlapping the Miocene formations and forming the surface materials throughout the upland region of the southern part of the county are 100 feet or less of coarse to fine, irregularly bedded sands and bluish sandy clays of undifferentiated Miocene to Pleistocene age, which weather to loose white or yellowish sands that cover the immediate surface to a depth of several feet. The shallow wells of the county tap water-bearing beds in these surface deposits.

Pleistocene terrace deposits consisting of sands and clays have been deposited in narrow areas bordering Savannah and Ogeechee rivers.

The Vicksburg formation is underlain by 400 to 500 feet of sands, clays, and marls belonging to the Claiborne group of the Eocene, and the Claiborne is underlain in turn by 500 feet or more of irregularly bedded sands and clays of Cretaceous age which rest upon crystalline basement rocks. The Eocene and Cretaceous deposits do not appear at the surface in the county, but their buried strata contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug or driven wells 15 to 60 feet deep are the chief sources of domestic water supply. Most of them yield soft waters, but a few in the valleys of Savannah River and Briar Creek in the north penetrate limestones and yield hard waters.

Artesian wells have been drilled at Dover, Hershman, and Halcyondale, near Mears, and at Millhaven, Rockyford, Sylvania, and Ogeechee.

A few small springs along Savannah River and elsewhere are of slight importance. Reddick Blue Spring, rising from limestone 6 miles northeast of Sylvania, is the only large spring in the county; its estimated yield is 500 gallons per minute. Eureka Spring, 12 miles south of Sylvania, is a picnic resort. (See analysis 2, Table 71.)

Artesian water can be obtained anywhere in the county at depths of 100 to 1,000 feet or more and will be more suitable for domestic use than other waters. Flowing wells can be obtained on the terrace plains bordering Ogeechee and Savannah rivers and Briar Creek. (See Pl. XVIII, p. 122.)

LOCAL SUPPLIES.

Sylvania (population, 1,400, census of 1910).—The town of Sylvania owns a public water-supply system which obtains water from an artesian well completed in 1911. The well is 320 feet deep and the principal water-bearing bed is at a depth of 210 feet; the water rises to within 100 feet of the surface but is said to be lowered 20 feet when pumped 150 gallons per minute. The water is hard but is used for domestic and boiler-supply purposes. A log of this well has been furnished by the Hughes Specialty Well Drilling Co. as follows:

Log of town well, Sylvania (No. 9, Table 70).

[Authority, J. R. Connelly, driller in charge.]

	Thickness.	Depth.
	Feet.	*Feet.*
Red clay	20	20
Clay and sand	40	60
Tough shell rock	20	80
Sand	20	100
Shell rock and marl	40	140
Sand	10	150
Layers of hard rock; yields a small amount of water at a depth of 190 feet	60	210
Soft shell rock, water bearing	20	230
Medium shell rock	60	290
Sand, noncaving	10	300
Alternating layers of shell rock and sand	20	320

A well owned by T. A. Marks, which formerly supplied the city, is 697 feet deep and yields 50 gallons of water per minute, which rises to within 70 feet of the surface. Hard rock is reported from 200 to 230 feet.

A well, reported as unsuccessful, owned by Mr. L. H. Hilton, is 285 feet deep; water obtained at 280 feet rises to within 80 feet of the surface. McCallie [1] has published the following log:

Log of well of L. H. Hilton, Sylvania (No. 12, Table 70).

	Thickness.	Depth.
	Feet.	*Feet.*
Red clay	60	60
Light-colored clay	100	160
Thin layers of hard rock interlaminated with coarse black sand to the bottom of the well	125	285

[1] Georgia Geol. Survey Bull. 15, pp. 161, 162, 1908.

At Sylvania artesian wells more than 800 or 900 feet deep are likely to yield larger supplies and softer waters than wells of less depth.

Rockyford (population 385, census of 1910).—Rockyford is in the western part of the county on a terrace plain lying about 35 feet above Ogeechee River and 130 feet above sea level. Seven[1] flowing artesian wells 180 or 185 feet deep have been drilled in the town; some of them flow 15 feet above the surface. The water obtained is hard and sulphurous but wholesome. Flows are first obtained at 100 feet and the yield increases as greater depths are reached. It is believed that the wells tap water-bearing beds in the Chattahoochee formation.

The town has no public water-supply system but owns a flowing well the reported depth of which is 185 feet. The static head is 10 or 12 feet above the surface, and although the well has been completed several years no material variation in the flow has been noted.

Dover.—Dover is near Ogeechee River at 104 feet above sea level. A 350-foot well owned by the Central of Georgia Railway[2] yields water which rises 19 feet above the surface. Water-bearing beds which furnish flows are reported at 125 and 225 feet. The water is used chiefly for the boiler supply of locomotives. The principal water-bearing bed is thought to be in either the Chattahoochee or Vicksburg formation of the Oligocene. (See analysis 1, Table 71.)

Millhaven.—Millhaven (Garnett), a trading town having a large cotton gin and cottonseed-oil mill, is on the Brinson Railway, on the bank of Briar Creek, near the north line of the county. The Comer Trading Co. owns seven deep wells four of which flow.

Two flowing wells near the post office and about 10 feet above Briar Creek are 286 and 298 feet deep and flow 14 feet above the surface. The principal water-bearing bed is said to be a sand at 280 feet. The water is said to be hard and sulphurous and is used chiefly for domestic purposes and for stock. Another water-bearing bed was encountered at 175 feet; hard rock was penetrated at a depth of 150 feet.

Mears.—Mears is a small village 3 miles east of Millhaven. On a plantation owned by Mears & Sanders, 3 miles northeast of the post office, a flowing well has recently been completed. The mouth of the well is 24 feet above Rocky Creek, a small tributary of Savannah River. The depth is 470 feet and the principal water-bearing bed is reported to be a hard shell marl or limestone at a depth of 371 feet that probably belongs to the McBean formation of the Claiborne group. (See analysis 3, Table 71.) W. J. Floyd, the driller, furnishes the following log:

[1] Georgia Geol. Survey Bull. 15, p. 161, 1908.
[2] Idem, pp. 163–164.

Log of well of Mears & Sanders near Mears (No. 4, Table 70).

	Thickness.	Depth.
	Ft. in.	*Ft. in.*
Sand	4 0	4 0
Clay	16 0	20 0
Coarse sand and pebbles	6 7	26 7
Whitish honeycomb rock	8 1	34 8
Red clay	8 4	43 0
White sand	51 8	94 8
White rock	0 9	95 5
Sand and clay	63 11	159 4
Rock	3 3	162 7
Sand and clay	6 11	169 6
Rock	5 10	175 4
Marl	5 4	180 8
Soft rock	2 4	183 0
Marl and layers of soft rock	35 6	218 6
Marl and clay	118 6	337 0
Soft rock	1 6	338 6
Marl	16 6	355 0
Hard rock	1 4	356 4
Marl and clay	5 6	361 10
Hard rock	1 2	363 0
Marl	4 0	367 0
Porous rock with good water-bearing beds	4 0	371 0
Marl and rocks	59 0	430 0
Clay	40 0	470 0

Hershman.—Hershman is a village near Savannah River, 22 miles northeast of Sylvania. A flowing well 3 miles to the southwest, owned by W. K. Harrison, is said by W. J. Floyd, the driller, to be 415 feet deep, 2½ inches in diameter, and to flow 18 gallons per minute 7 feet above the surface. The elevation of the mouth of the well is not known, but it is probably 50 to 75 feet above Savannah River. The water, which is said to be hard, is used for domestic purposes on a plantation.

Log of well of W. K. Harrison, Hershman (No. 3, Table 70).

[Authority, W. J. Floyd.]

	Thickness.	Depth.
	Feet.	*Feet.*
Red and yellow clay	39	39
White pipe clay	2	41
Gravel, sand, and pebbles	2.5	43.5
Red and yellow clay	14.5	58
Soft rock and shells	4	62
Sand and soft limestone	20	82
Hard rock	2	84
Coarse sand and gravel	3	87
Soft limestone with small water-bearing beds; good supply of water rises to within 18 feet of the surface	5	92
Sand	16	108
Sand and clay	2	110
Sand with some yellow clay	31	141
Soft rock	3	144
Hard rock	4	148
Clay	5	153
Soft rock	10	163
Clay	10	173
Soft rock	3	176
Clay	5	181
Gray marl	18	199
Soft rock	4	203
Very hard rock; used dynamite to shatter	4	207
Marl	26	233
Marl, partly indurated in some layers	108	341
Hard rock	2	343
Marl and soft rock; water at 362 feet flowed 8 gallons per minute 3 feet above surface	19	362
Marl and layers of rock, water bearing; flows 18 gallons per minute 7 feet above surface	53	415

Specimens of borings from 210 and 343 feet are hard shell marl or impure limestone similar to rock of the McBean formation exposed in bluffs of Savannah River in Burke County.

TABLE 70.—*Wells in Screven County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Dover	Central of Georgia Ry.		S. W. McCallie[a]	1903	104
2	Halcyondale	E. S. Marsh		Postmaster		110
3	Hershman, 3 miles southwest of.	W. K. Harrison	W. J. Floyd	W. J. Floyd		
4	Mears, 3 miles northeast of.	Mears & Sanders	do	do		(b)
5	Millhaven		E. L. Edenfield.	E. L. Edenfield	1908	(c)
6	Ogeechee	Town		A. B. Lovett, Sylvania, Ga.		111
7	Rockyford	do	T. D. Lloyd	Oliver Parker		130
8	do			S. W. McCallie[a]		130 (d)
9	Sylvania	Town	Hughes Specialty Well Drilling Co., Charleston, S. C.; J. R. Connelly, driller in charge.	Hughes Specialty Well Drilling Co.	1911	
10	do	Sylvania Water Supply Co.		A. B. Lovett		
11	do	T. A. Marks		S. W. McCallie[a]	1895	
12	do	L. H. Hilton		do	1895	

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	350	3	125, 225		+ 19			Flows	See Table 71, analysis 1.
2	290 (?)				− 12			Sand pump	
3	415	2½	362–415	87–92	+ 7	18		Flows	Hard.
4	470		371						See Table 71, analysis 3.
5	286	4½	280	175	+ 14	40		Flows	Hard, slightly sulphurous.
6								do	
7	185	4	185		+ 12				Sulphurous.
8	180	4	100–180		+ 15			Flows	Hard, sulphurous.
9	320	8	210–230	190	−100		150		Slightly hard.
10	400		350		− 90			Deep-well pump	Hard.
11	697	4			− 70		50		Slightly hard.
12	285	3	280		− 80				

[a] Georgia Geol. Survey Bull. 15, pp. 161–164, 1908.
[b] Elevation about 24 feet above low-water level of Rocky Creek.
[c] Elevation about 10 feet above low-water level of Briar Creek.
[d] Elevation about 35 feet above low-water level of Ogeechee River.

TABLE 70.—*Wells in Screven County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Supply of locomotive boilers.	Oligocene (?)		Cost of well, $300.
2	Domestic	Chattahoochee formation (?)		
3	do	McBean formation		See log, p. 381.
4		do	Hard shell rock	See log, p. 381.
5	Domestic, manufacturing.	do	Sand	4½-inch casing to 150 feet. Cost of well, about $400. Mr. Edenfield has drilled 3 other flowing wells and 3 nonflowing wells for the Comer Trading Co. near Millhaven.
6				
7	Domestic	Chattahoochee formation (?)	Sand	Cost of well, $200.
8		do		Seven 4-inch flowing wells have been drilled at and near Rockyford, all about 180 feet deep.
9	Municipal supply.	Oligocene	Soft shell rock	8-inch casing, 150 feet; cost of well, $1,200; of machinery, $1,200. See log, p. 379.
10	Former municipal supply.	Oligocene or Eocene.		
11	Domestic	Eocene		Cost of well, $900.
12	Not used			Cost of well, $350. See log, p. 379.

TABLE 71.—*Analyses of underground waters from Screven County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1		Well of Central of Georgia Ry.	Dover	Oligocene?	350	Edgar Everhart.[a]
2	July, 1909	Eureka Spring, owned by H. S. White.	Eureka Spring, 12 miles south of Sylvania.	Surficial deposits.		Do.
3	Apr. 25, 1911	Well of Mears & Sanders.	Mears, 3 miles northeast of.	McBean formation.	470	Do.

No.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Remarks.
1	50	[b]4.2	.....	36	6.2	20	7.1	.....	149	3.9	.....	29	229	Well 1, Table 70.
2	5.2	6.3	0.1	1.4	.2	3.4	.4	.....	61	1.4	.....	5.0	33	
3	28	1.0	.....	44	2.0	14		0.0	156	6.0	Tr.	3.5	190	Well 4, Table 70.

[a] Georgia Geol. Survey Bull. 15, pp. 163, 164, 1908.

[b] $Fe_2O_3+Al_2O_3$.

STEWART COUNTY.

GENERAL FEATURES.

Stewart County is in the northwestern part of the Coastal Plain of Georgia. Its area is 411 square miles and its population 13,437 (census of 1910). The chief industry is agriculture.

TOPOGRAPHY.

The county lies in the physiographic division of the fall-line hills. In greater part it is more or less broken and hilly, being the result of the dissection of an upland plain. Bordering Chattahoochee River are two small Pleistocene terrace plains whose limits have not been determined in detail. The lower (the Satilla) lies 40 to 50 feet above low-water level of Chattahoochee River, and the higher (the Okefenokee) lies 110 to 130 feet above the same datum.

The drainage of the county is received by Chattahoochee River through its tributaries, Pataula, Hannahachee, Hichetee, and several smaller creeks. The maximum topographic relief of the county is believed to be at least 400 feet and may exceed that amount.

GEOLOGY.

Upper Cretaceous, Eocene, and Pleistocene deposits are the surface formations. The Tombigbee sand member of the Eutaw formation, which consists of about 120 feet of massive, more or less calcareous and glauconitic sands and interbedded clays with indurated layers at intervals, outcrops in the bluffs of Chattahoochee River in the extreme northwestern part of the county. This member is conformably underlain by 400 or 500 feet of sands and clays, which are also referable to the Eutaw formation but which do not appear at the surface within the county. The Eutaw formation is underlain unconformably by Lower Cretaceous sands and clays, probably not less than 500 feet thick, which rest upon deeply buried crystalline basement rocks.

The Tombigbee sand member of the Eutaw formation is conformably overlain by the Ripley formation, which has an estimated thickness of 950 feet. Immediately along the river the formation is made up of beds of sand, clay, and marl of marine origin. These beds are more or less glauconitic and calcareous and contain some lignite. They are in part loose and irregularly bedded and in part compact and massive. Northeastward the lower part of the formation merges horizontally into the irregularly bedded shallow-water sands and clays of the Cusseta sand member. The upper 125 or 150 feet of the formation consists of irregularly bedded, coarse to fine sands with subordinate clay lenses of shallow-water origin which have been designated the Providence sand member of the formation. This member outcrops in a belt a few miles wide, extending from a point near the southwest to the northeast corner of the county.

The Providence sand member is overlain unconformably by the Midway formation (Eocene), which appears at the surface over approximately the southeastern half of the county. The Cretaceous and Eocene strata all incline southeast 20 to 40 feet to the mile. (See Pl. III, p. 52.)

Pleistocene loams, sands, and gravels 15 to 30 feet in thickness have been laid down as terrace deposits on two terrace plains in small areas bordering the river. One of these plains lies 40 to 50 feet and the other 110 to 130 feet above low-water level. Their extent is not known in detail.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Water for domestic purposes is derived chiefly from dug wells 20 feet to over 100 feet deep. On the terraces bordering Chattahoochee River shallow wells 20 to 30 feet deep draw sufficient water for ordinary domestic purposes from the sands and gravels at the base of the Pleistocene deposits. Because of the absence of impervious strata between this horizon and the earth's surface there is constant danger of contamination from surface sources, especially where wells are near dwellings or stables. On the hilly upland region east of Chattahoochee River, which makes up the greater part of the surface of the county, it is necessary to sink the wells 100 feet or more. On the hill slopes and in the small valleys water is obtained at less depth.

Small springs are common throughout the hilly parts of the county and are used to some extent. In general they yield waters of good quality unless locally contaminated by too close proximity to dwellings or other sources of decaying organic matter. In the belt of typical marine strata of the Ripley formation the spring waters are apt to be more or less charged with lime, iron, and sulphur.

In the southeastern half of the county water of good quality is available in considerable quantities from the Providence sand member of the Ripley formation. Along the belt of outcrop running northeast-southwest through the center of the county the water-bearing beds of this member are tapped by numerous shallow wells. To the southeast the same beds should be reached at slightly increasing depths beneath the Eocene strata. The quantity of water available probably increases in the same direction away from the catchment area.

The Cusseta sand member of the Ripley formation, which outcrops over the greater part of the northwestern third of the county, is a possible source of artesian supply to the east and southeast of its catchment area. Here it is necessary to drill through the overlying typical marine beds of the formation, or still farther to the southeast through the overlying Eocene strata, the Providence member of the Ripley formation, and the typical marine beds of the Ripley formation. The depth of the beds increases to the southeast but probably does not exceed 700 or 800 feet within the county.

38418°—wsp 341—15——25

In the western part of the county good water is obtained by drilling through the basal strata of the Ripley formation and the Tombigbee sand member of the Eutaw formation into the irregularly bedded sands and clays of the Eutaw, which are reached at 200 to 700 feet. The wells owned by W. C. Bradley near Omaha and near Coffinton tap these Eutaw beds.

Flowing wells are possible only on the lowest Pleistocene terrace bordering Chattahoochee River, at elevations less than 60 feet above low-water level.

LOCAL SUPPLIES.

Lumpkin (population 1,140, census of 1910).—Mayor W. L. Mardre has furnished information concerning the water plant owned by the town. The supply is derived from springs a mile to the southwest and is stored in a reservoir having 40,000 gallons capacity. From the reservoir it is pumped into a tank of like capacity located in the town. The capacity of the pump is 500 gallons per minute, and there is a duplicate boiler and pump for use in emergencies. The length of the distributing mains is 3½ miles, the tank pressure is 45 pounds, and the direct pressure from the pumps is 50 pounds. The daily amount used is 40,000 gallons (124 taps) for domestic purposes and 10,000 gallons for manufacturing purposes (3 taps). There are also 22 fire hydrants. The water is soft and the supply satisfactory.

The springs emerge from the Providence sand member of the Ripley formation. (See analysis 2, Table 73.)

Detailed information concerning a well (No. 5, Table 72) owned by C. H. Humber, located 3⅛ miles east of south of Lumpkin, is furnished by Mr. M. Walton. (See analysis 3, Table 73.)

Log of well of C. H. Humber, 3⅛ miles east of south of Lumpkin (No. 5, Table 72).

	Thickness.	Depth.
Eocene (?), Midway formation (?):	*Feet.*	*Feet.*
Red clay	30	30
White sand	100	130
White rock	6	136
Dry cavity	8	144
Cretaceous (?), Ripley formation, Providence sand member (?):		
White, yellow, and bluish sands, with interbedded thin layers of rock; water-bearing sands, especially at 145, 200, 245, and 290 feet, the latter being the principal one; the last 100 feet contained more or less water throughout	190	334

Richland (population 1,250, census of 1910).—Richland owns a municipal water-supply system which obtains water from a well 425 feet deep (No. 12, Table 72; for analysis see Table 73, analysis 4). The water is distributed from a tank the pressure of which is 52 pounds; the direct pressure from the pump is 100 pounds; the length of the water mains is 4 miles. There are 75 taps and 35 fire hydrants. The water is somewhat sulphurous. As to both quality and quantity, the water supply is said to be satisfactory.

Omaha.—On the plantation of W. C. Bradley, 5 miles north of Omaha, near Chattahoochee River, are four wells (Nos. 6 to 9, Table 72). Three of these, located on the lowest Pleistocene terrace bordering the river, are 270 feet deep and afford flows; the fourth, located on higher ground, is 315 feet deep and does not flow; the water of this well is pumped by a windmill to a tank holding 15,000 gallons and is used for stock, fire protection, and other plantation purposes. All are believed to tap approximately the same water-bearing bed in the Eutaw formation. An analysis of the water from one of these wells is given in Table 73 (analysis 1).

Daniel Bradley, who owns another well (No. 10, Table 72) in the same vicinity, furnishes the following log:[1]

Log of well of Daniel Bradley, near Julia (No. 10, Table 72).

	Thickness.	Depth.
	Feet.	*Feet.*
Clay	12	12
Sand	60	72
Marl, with here and there a stratum of hard rock, water bearing at 475 feet	668	740

This well penetrates an undetermined thickness of strata referable to the Ripley formation, passes entirely through the Eutaw formation, and enters the uppermost Lower Cretaceous deposits. The principal water-bearing stratum, 475 feet deep, is probably in the irregularly bedded portion of the Eutaw formation below the Tombigbee sand member.

Coffinton.—On another plantation, owned by W. C. Bradley near Coffinton, a well 660 feet deep (No. 2, Table 72) flows 25 gallons per minute, supplying the needs of a large plantation on which there are about 250 tenants. Mr. Bradley states that there are several flowing wells in the area between Coffinton and Omaha.

Other localities.—The logs and descriptions of a number of dug wells which penetrate Cretaceous strata are given on the following pages. In each case the authority for the lithology is the owner unless otherwise stated:

Log of well of J. B. Simpson, 2½ miles south of Lumpkin (No. 3, Table 72).

	Thickness.	Depth.
Eocene (?):	*Feet.*	*Feet.*
Red clay	90	90
Upper Cretaceous, Ripley formation, Providence sand member (?):		
Soft "chalk" [clay]	15	105
Sand, water bearing	1	106

[1] Georgia Geol. Survey Bull. 15, p. 165, 1908.

Log of well of W. S. Boyett, 4 miles west of Lumpkin (No. 4, Table 72).

	Feet.
Eocene (?):	
Red clay	30
Upper Cretaceous, Ripley formation, Providence sand member:	
"Chalk" [clay] white and pink	?
Coarse sand with small rock (pebbles)	?
"Chalk" [clay]	?
Thick layer of white sand	?
("And so on until water was struck.")	
	70

In another well, 132 feet deep, 25 yards from the preceding, water was obtained in coarse sand 128 to 132 feet below the surface. Probably all the strata penetrated in this well below the red Eocene clay should be referred to the Providence sand member of the Ripley formation.

Log of well of Mrs. Marian Glenn, 1 mile southeast of Brooklyn (No. 1, Table 72).

	Thickness.	Depth.
	Feet.	*Feet.*
Eocene (?):		
Red clay with gravel rock [pebbles]	30	30
Upper Cretaceous, Ripley formation, Providence sand member:		
"Chalk" [clay]	10	40
White and yellow sand; some beds of rock 4 to 5 feet thick; water bearing at base (stopped on "chalk" [clay])	70	110

A well 140 feet deep, 50 feet from the preceding, is said to have penetrated similar materials.

G. L. Walton, of Charles, Ga., owns two wells, one 65 feet deep, near the station at the level of the track (Seaboard Air Line Railway), and another 85 feet deep, seven-eighths of a mile east of the station, 80 feet above the level of the track. Mr. Walton states that "the land is underlain with hard marl and no one in the neighborhood has ever been able to carry a well through it." This marl belongs to the typical marine portion of the Ripley formation.

Log of well of E. H. Acker, 2 miles southwest of Charles.

	Thickness.	Depth.
	Feet.	*Feet.*
Upper Cretaceous, Ripley formation:		
Sand	10	10
Hard dark-brown and gray streaked clay with one small layer of sand, water bearing (stopped on black marl)	16	26

Mr. Acker states that the black marl has been encountered in other wells in this neighborhood.

Log of well of E. M. Averett, one-quarter of a mile east of Renfroes (No. 11, Table 72).

[Authority for lithology, C. V. Stephens, Renfroes.]

	Thickness.	Depth.
Upper Cretaceous, Ripley formation, Providence sand member:	*Feet.*	*Feet.*
Sand, gray or white	8	8
Light-yellow firm clay	18	26
Soft yellow sand	30	56
Sand and clay, water bearing	4	60

Mr. Stephens states that 1½ miles west of Renfroes blue marl is entered at 10 to 15 feet and that wells 90 feet deep have not penetrated its entire thickness. This marl belongs to the typical marine portion of the Ripley formation.

TABLE 72.—*Wells in Stewart County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Brooklyn, 1 mile southeast of.	Mrs. Marian Glenn	.....	J. M. Glenn, Brooklyn.	1889	600
2	Coffinton, 1 mile southwest of, on the Rankin place.	W. C. Bradley, Columbus, Ga.	John R. Chapman, Columbus.	Owner	1911	215±
3	Lumpkin, 2½ miles south of.	J. B. Simpson	John Usher	....do	1890	600
4	Lumpkin, 4 miles west of.	W. S. Boyett	Andrew Thomas, Lumpkin.	....do	1886	550
5	Lumpkin, 3¼ miles east of south of.	C. H. Humber	Harper Reeves, Preston.	M. Walton	1912	.....
6	Omaha, 5 miles north of.	W. C. Bradley, Columbus.	L. B. Clay, Bartow.	Owner	1895	210±
7	....do	....do	....do	....do	1895	210±
8	....do	....do	....do	....do	1895	210±
9	....do	....do	....do	....do	1895	.....
10	....do	Daniel Bradley	.....	S. W. McCallie[a]	.....	
11	Renfroes, ¼ mile east of.	E. M. Averett	.....	C. V. Stephens, Renfoes.	1888	660?
12	Richland	Town	.....	S. W. McCallie[a]	1898	600

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	110	36	110	.....	−107	.....	¼	Rope and bucket	
2	660	6	660	.....	+30	25	.....	Flows	Ferruginous and sulphurous.
3	106	48	106	40	−102	.....	.....	.....	Clear, hard.
4	132	36	128	60	−128	.....	.....	.....	Soft, freestone.
5	334	2	290	145 200 245	−150	.....	20	Deep-well pump	See Table 73, analysis 3.
6	270	4.5	.....	.....	+3	20	.....	Flows	Sulphurous and ferruginous.
7	270	4.5	.....	.....	+9	30	.....	....do	Do.
8	270	4.5	.....	.....	+22	40	.....	....do	Do.
9	315	4.5	.....	.....	−16	.....	35	Windmill	Do.
10	740	3	475	.....	.....	.....	.....	.....	Strongly sulphurous.
11	60	36	57	.....	−56	.....	Small.	Bucket and rope	Soft.
12	425	6	.....	.....	−100	.....	50	Steam pump	Sulphurous. See Table 73, analysis 4.

[a] Georgia Geol. Survey Bull. 15, p. 165, 1908.

TABLE 72.—*Wells in Stewart County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Providence sand member of Ripley formation.	Sand	Dug, cased; cost $50. See log, p. 388.
2	Domestic and boiler supply.	Eutaw formation	do	Cost of well, $1,200; 6-inch casing to 300+ feet. Furnishes water for 250 tenants.
3	Domestic	Providence sand member of Ripley formation?	do	Dug, cased 30 feet; cost $20. See log, p. 387.
4	do	Ripley formation (Providence sand member).	Coarse sand	Dug, cased 30 feet. See log, p. 388.
5	do	Ripley formation	Sand	3-inch casing to 300 feet; cost of well and machinery, $360. See log, p. 386.
6	Domestic and boiler supply.	Eutaw formation	do	On lowest Pleistocene terrace bordering Chattahoochee River; cost of wells 6, 7, 8, and 9, each, $350. Wells cased for 100 to 150 feet. Not permitted to flow when not in use.
7	do	do	do	
8	do	do	do	
9	do	do	do	On hill above river terrace, probably 300 feet or more above sea level; cost of windmill, $250.
10	Domestic	do		See log, p. 387.
11	do	Ripley formation (Providence sand member).	do	Dug, partly cased; cost $3,600. See log, p. 389.
12	Municipal supply	Ripley formation		Hard rock at 300 feet.

TABLE 73.—*Analyses of underground waters from Stewart County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	June 4, 1911	Wells of W. C. Bradley.	Omaha, 5 miles north of.	Eutaw formation	270	Edgar Everhart.
2	May 5, 1911	Town springs	Lumpkin, 1 mile southwest of.	Ripley formation (Providence sand member).	.....	Do.
3	Jan. 13, 1913	Well of C. H. Humber.	Lumpkin, 3½ miles east of south of.	Ripley formation.	290	Do.
4	Mar. 28, 1911	Town well	Richland	Ripley formation	425	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na + K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Remarks.
1	26	0.2	12	0.5	62	7.0	170	23	0.2	5.0	197	Wells 6, 7, 8, 9, Table 72.
2	4.0	Tr.	2.0	.5	5.0	.0	12	Tr.	1.2	2.5	.....	
3	23	4	50	4	14	.0	198	12	.1	3	211	Well 5, Table 72.
4	24	1.1	47	4.4	7.2	.0	178	11	3.0	4.0	209	Well 12, Table 72.

SUMTER COUNTY.

GENERAL FEATURES.

Sumter County is in the western part of the Coastal Plain of Georgia. Americus, the county seat, is 62 miles southwest of Macon and 48 miles east of the Alabama line. The area of the county is 456 square miles and the population (census of 1910) is 29,092. Agriculture is the principal industry. Cottonseed-oil mills, fertilizer factories, and other small manufacturing plants are located at Americus. Lumbering and turpentining, though declining in importance, are still carried on.

TOPOGRAPHY.

The northern part of the county is somewhat hilly and broken, owing to the rapid erosion of underlying unconsolidated sands and clays; the western part, in the vicinity of Plains, is nearly level; the southwestern and eastern parts are slightly undulating and less broken than the northern; the southeastern part is nearly flat, is covered with a few feet of loose gray sand, and contains many lime sinks and cypress ponds. Flint River, which forms the eastern boundary, is bordered by two Pleistocene terrace plains, the "swamp" or second bottoms lying 10 to 15 feet and a sand-covered plain less clearly defined lying 50 to 75 feet above the river.

Flint River, Muckalee and Kinchafoonee creeks, and their numerous small tributaries drain the county. Flint River rises in the Piedmont Plateau and is always more or less turbid from suspended silt and clay. The other streams originate in the Coastal Plain and flow through shallow swampy valleys; their waters are dark, owing to their high content of organic matter.

The known elevations above sea level are Americus, 360 feet; Andersonville, 394 feet; and Sumter, about 372 feet. The highest land in the northern part of the county probably lies 400 or 450 feet above sea level, and the lowlands along Flint River probably lie about 200 feet above the same datum plane.

GEOLOGY.

The surface formations of the county are of Tertiary age and belong in part to the Eocene and in part to the Oligocene. The Eocene deposits, which have not been accurately discriminated, consist of sands, clays, marls, and limestones several hundred feet in thickness. They outcrop in the north and northwest, and extend southward in the valleys of Flint River, and of Muckalee and Kinchafoonee creeks, to or beyond the southern boundary of the county.

Surface observations in this and adjoining counties seem to indicate that the Eocene deposits are divisible in ascending order into the Midway and Wilcox formations, the Claiborne group, and the Jackson formation. However, the interpretation of the age of the strata penetrated in city well No. 4 at Americus, as given in the partial log on pages 394–395, indicates that at Americus the total thickness of the Eocene is only 200 feet, and that at least 157 feet of this thickness belongs to the Jackson formation. If this be true only 43 feet of strata remain to represent the Midway and Wilcox formations and the Claiborne group, which, according to the evidence afforded by surface outcrops, intervene between the Cretaceous and Vicksburg formations. Either great unconformities exist which cut out some of the formations locally, or the formations have not been correctly correlated.

Over the central, southern, and southeastern parts of the county the Vicksburg formation (Oligocene) appears at the surface except in the immediate valleys of the larger streams. The terrane, which consists mainly of heavy-bedded, soft, cavernous, water-bearing limestones and interbedded water-bearing sands 200 to 250 feet thick, weathers to red argillaceous sands which at many places contain masses of fossiliferous flint. Pleistocene terrace deposits have been laid down in small areas bordering Flint River.

The Eocene deposits are underlain by 800 to 1,000 feet of sands, clays, and marls (Ripley formation of the Upper Cretaceous), which do not appear at the surface within the county.

The Ripley formation is underlain by several hundred feet of undifferentiated strata of Cretaceous age, which rest upon a deeply buried basement of ancient crystalline rocks. The Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The principal sources of domestic water supply are dug and bored wells from 20 to 100 feet deep. The waters are soft and are of good quality if the wells are properly curbed or cased to prevent contamination from surface sources. Artesian wells are preferable, however, because they afford less opportunity for pollution and are less apt to be affected by drought.

Artesian wells have been drilled at Americus, near Huguenin, at Leslie, old Danville, Plains, and Sumter, and near Andersonville.

Small springs are fairly numerous in the northern part of the county and many of them are perennial. In Americus a portion of the water supply is taken from small springs, and in the rural districts

springs are used locally for domestic supplies. The spring waters usually contain less mineral matter than the artesian waters, but many of them are rather strongly ferruginous. The better-known springs are Magnolia, Myrtle, Sweetwater, and Providence, the latter being the historic spring of the Confederate prison at Andersonville.

The waters of streams and ponds are used locally for watering stock and for boiler supply.

Artesian water can be obtained anywhere at depths of 100 to 1,000 feet or more. In the south large supplies may be obtained from cavities or beds of sand in the Vicksburg formation at depths of 250 feet or less. The Eocene deposits, which underlie the Vicksburg formation in the south and come to the surface in the north, contain water-bearing beds, and beneath the Eocene at still greater depths the Cretaceous deposits carry numerous important water-bearing beds. The prospects are good for obtaining flowing wells along Flint River at elevations less than 75 feet above low-water level and in the lowlands south of Americus.

LOCAL SUPPLIES.

Americus (population 8,063, census of 1910).—At Americus the public water supply is derived in part from artesian wells and in part from springs. The city artesian wells are four in number and are located on the north side of Town Creek one-half mile north of the county courthouse. (See Pl. XX, *B*, p. 240.)

Well No. 1 is 337 feet deep, and the water stands within 65 feet of the surface. The casing rusted out and was recently replaced to a depth of 245 feet, but was prevented from going deeper by an obstruction. The water in the well at the time of Mr. Veatch's visit (April, 1911) was turbid, and when the pumps were started large quantities of gray lignitic quartz sand were forced out.

Well No. 2 is 450(?) feet deep and the water rises to within 60 feet of the surface. Originally the water stood within 16 feet of the surface, but wells subsequently drilled to about the same depth at the Central of Georgia Railway station and at the fertilizer factory are believed to have caused the static head to sink to its present position.

Well No. 3 is about 700 feet deep and yields a slight flow above the surface.

Well No. 4 was drilled in 1907 (?) and is 992 feet deep, 10-inch casing was inserted to 226 feet, 8-inch casing to 402 feet, and 6-inch casing to 962 feet. The principal water-bearing bed is between 962 and 992 feet and the water rises to within 60 feet of the surface. From data and a few samples in the office of J. B. Ansley, superintendent of the city waterworks, Mr. Veatch has prepared the following log:

Log of city well No. 4, Americus (No. 4, Table 74).

	Thickness.	Depth.
	Feet.	*Feet.*
Sand	10	10
Bluish and drab sandy micaceous clay	60	70
Coarse white sand, water bearing	8	78
Gravel	2	80
White glauconitic sandy limestone; fragments of shells; Ostrea	26	106
Limestone containing shells and corals (?)	4	110
Flinty formation, contains shells	3	113
Slightly glauconitic shell marl	2	115
Black clay	29	144
Medium-grained sandlike material consisting chiefly of fragments of limestone with scattered quartz grains and some glauconite	3	147
Very sandy glauconitic limestone; shells	5	152
Sandy limestone or calcareous sandstone	5	157
Clean white sand, water bearing	23	180
Gray micaceous very sandy clay	45	225
Hard calcareous quartzite	8	233
Marl (probably sandy clay)	22	255
Sand, gravel, and conglomerate	20	275
Fine white sand and gravel	34	309
Flint (quartzite) containing shells	4	313
Fine brownish sand, some shell marl	8	321
Fine white sand, water bearing	17	338
Flint (quartzite) and shell conglomerate	20	358
Fine gray sand containing a little clay	18	376
Soft limestone rock	166	542
Fine sharp sand, water bearing	3	545
Very fine quartz sand, water bearing	112	657
Soft black marl (clay)	10	667
Sand	20	687
Marl (clay)	15	702
Fine gray sand. This stratum flows 8 gallons a minute	188	890
Marl (clay) containing a small amount of fragments of shells; bottom of casing	72	962
Water-bearing strata	30	992

Since the preceding log was prepared Mr. Stephenson has obtained from Mr. Ansley a partial set of well borings of well No. 4, on the basis of which the following partial log has been prepared:

Partial log of city well No. 4, Americus (No. 4, Table 74).

[Total depth, 992 feet.]

	Feet.
Eocene:	
Jackson formation (?):	
Brown very sandy clay at	60
Light-gray very coarse sand	60– 68
Jackson formation:	
Gray sandy limestone with numerous fragments of shells, chiefly Gryphæa sp.; contains also the bryozoan *Idmonea maxillaris* Lonsdale[1]	80–106
Small fragments of slightly glauconitic sandy limestone with numerous fragments of shells and some scattered grains of quartz sand	113–115
Loose, medium-grained, sandlike material consisting chiefly of fragments of limestone with scattered grains of quartz and some glauconite; contains Heteropora sp. nov.[1]	144–147
Mixture of fragments of sandy, slightly glauconitic limestone, fragments of shells, and quartz sand; contains Heteropora sp. nov.[1] (same species as in the preceding sample) and *Lunatia eminula* Conrad[2]	141–152

[1] Identified by R. S. Bassler, who states that the age indicated is Jackson (Eocene).
[2] Identified by T. W. Vaughan, who states that the age indicated is Eocene.

Eocene—Continued.	Feet.
Coarse clear quartz sand with numerous fragments of gray sandy limestone	152–157
Eocene (?):	
Not represented by sample but probably Eocene	157–180
Coarse gray argillaceous, micaceous, calcareous sand, with angular pebbles up to one-quarter of an inch in length; possibly a basal conglomerate	180–200
Upper Cretaceous, Ripley formation (?):	
Dark-gray sandy, micaceous, calcareous clay with fragments of shells	200–225
Upper Cretaceous, Ripley formation:[1]	
Fragments of hard gray calcareous, fossiliferous sandstone and a few loose shells and fragments of shells; recognized Breviarca sp. Nemodon?, *Ostrea tecticosta* Gabb?, Cardium sp., Crassatellites sp., Lithophaga sp	225–238
Fragments of gray calcareous sandstone and fragments of shells; recognized Exogyra sp., *Anomia argentaria* Morton, *Anomia lintea* Conrad	255–273
Yellow fine-grained quartz sand	273–309
Fragments of hard calcareous sandstone and numerous fragments of shells; recognized *Ostrea tecticosta* Gabb and *Ostrea subspatulata* Forbes? (young individual)	309–313
Mixture of yellow sand, fragments of hard gray calcareous sandstone, fragments of dark-gray shaly clay, and fragments of shells; recognized *Ostrea tecticosta* Gabb, Exogyra sp., *Anomia argentaria* Morton, *Anomia lintea* Conrad, *Lima reticulata* Forbes?	313–321
Fine gray sand containing numerous fragments of hard gray calcareous sandstone and a few fragments of shells; recognized Cheilostomatous bryozoa (identified by E. O. Ulrich), Exogyra sp., and *Anomia argentaria* Morton	358–376

The city springs are on the west side of Town Creek, north of the city wells and 1¾ miles north of the courthouse. They issue from a ferruginous quartz sand which outcrops at the base of the hills along the edge of the creek swamp. There were, originally, several natural springs at this locality, but the 42 so-called springs now in use have been developed by sinking shallow holes and are really shallow wells. Each spring is walled in the manner of a cistern or well and is covered by an iron lid which is kept closed and locked to prevent contamination. The water (150 gallons per minute) flows by gravity from the springs to the pumping station at the city artesian wells. The spring waters are probably safe, but will probably be contaminated if many more houses or factories are built in the vicinity.

Waters from wells Nos. 1 and 4 and from the city springs were analyzed (Table 75, analyses 1, 2, and 3). The two well waters, which are similar in composition, would be classed as hard and, on account of their high calcium content, are poor for boiler supply unless softened; each emits a slight odor of hydrogen sulphide. The spring

[1] Fossils identified by L. W. Stephenson except as otherwise indicated.

waters are softer and contain much less mineral matter than the well waters.

There are several other artesian wells in the vicinity of Americus. One, owned by the Central of Georgia Railway, located near the station on the lowland along Town Creek, is reported to be 480 feet deep. It flows a small stream.

A well was drilled in 1883 on the present site of Windsor Hotel. Reports differ as to its depth; McCallie [1] states that it was 1,725 feet deep and that at 1,000 feet water was encountered which rose to within 30 feet of the surface. The well was abandoned because it did not flow.

A well on the public square is reported to be 900 feet deep and is nonflowing.

The log of a well (No. 11, Table 74) owned by Dr. P. F. Bahnsen, 1½ miles south of Americus, has been furnished by the owner as follows:

Log of well of Dr. P. F. Bahnsen, 1½ miles south of Americus.

[Authority, J. J. James, driller.]

	Thickness.	Depth.
	Feet.	*Feet.*
Red clay	15	15
Sand and clay mixed	25	40
Sand, water bearing	20	60
Purple clay	20	80
Sand and blue marl	10	90
Blue marl	40	130
White limestone in hard and soft layers; water-bearing cavity at a depth of 177 feet	50	180

The water-bearing cavity at 177 to 180 feet is probably in limestone of the Jackson formation. An analysis of the water is given in Table 75 (analysis 4).

A well owned by T. B. Hooks, 5 miles southeast of Americus, is reported to be 450 feet deep. The water stands within 40 feet of the surface and is said to be hard; when exposed to the atmosphere an oily scum probably due to iron oxide appears on the surface. Rock was encountered at 40 feet, but the principal water supply is said to come from sand at a depth of 340 feet. The water is pumped by means of a gasoline engine and supplies a plantation.

McCallie [2] gives the following additional well data:

In addition to the wells above described there are two wells near the city limits of Americus, one of which is owned by Mr. E. C. Speer and located 1½ miles north of Americus. This well is 4 inches in diameter and 212 feet deep. The water, which is said to be apparently inexhaustible, rises to within 102 feet of the surface and is used for drinking purposes, also to supply a ginnery and a sawmill. The other well, owned by Messrs. Perry & Brown, is 2½ miles southeast of Americus.

[1] Georgia Geol. Survey Bull. 15, p. 166, 1908.
[2] Idem, pp. 168, 169.

It is 284 feet deep and 4 inches in diameter. The water rises to within 100 feet of the surface. Both the Speer well and the Perry & Brown well are located on elevated ground, which accounts for the low static head of the water. Hard rock is reported in the Perry & Brown well at 270 feet. Above the rock occur sands, clays, and marls. The principal water supply is said to come from a cavity 2 or 3 feet deep in the rock at the bottom of the well. A second water-bearing stratum is reported at 100 feet, but this is cased off, and the only water used is from the first-mentioned stratum. The water, which is elevated by the means of a deep-well pump, operated by a windmill, is used for general farm purposes. It is said to contain iron and sulphur.

Plains (population 400, census of 1910).—The town of Plains has no water-supply system but owns a deep well from which a part of the inhabitants obtain their domestic water supply. The well, drilled in 1910, is near the Seaboard Air Line Railway station and is 244 feet deep and 3 inches in diameter. The water, which is hard and ferruginous, is said to come from a cavity at 243 feet and rises to within 85 feet of the surface; it is lowered 10 feet by pumping 10 gallons per minute. T. J. James furnishes the following log of the well:

Log of the town well at Plains.

	Thickness.	Depth.
	Feet.	*Feet.*
Clay	20	20
Sand and clay	60	80
Purple marl (clay)	10	90
Blue marl (clay)	60	150
Sand with black specks, water bearing	10	160
Blue marl (clay)	10	170
Rock	10	180
Thin layers of rock and marl	40	220
Rock	10	230
Thin layers of rock and white marl with hard flinty places (clay)	14	244

Eight wells in and near the town range in depth from 244 to 280 feet A well owned by J. D. Clark and T. J. Spann is 265 feet deep and is cased to a depth of 150 feet; the water probably comes from the upper part of the Midway formation. (See analysis 5, Table 75.) The following is an approximate log:

Log of well of J. D. Clark and T. J. Spann, Plains.

	Thickness.	Depth.
	Feet.	*Feet.*
Sand and clay	90	90
Compact bluish or grayish argillaceous sand or sandy clay	75	165
Sand and "marl" or clay with some shell rock	75	240
Thin layers of hard rock, limestone (?); water bearing	25	265

Magnolia Spring.—Magnolia Spring, which has a local reputation, is about 3½ miles north of Plains. The yield has not been accurately measured but is, perhaps, 30 or 35 gallons per minute. The water issues from a gray argillaceous, micaceous, slightly calcareous sand

(Wilcox), containing iron sulphide and bits of lignitic matter, which outcrops in a small valley near the head of a small creek. The water is slightly sulphurous and is rather hard and high in iron; it is, however, a wholesome drinking water. (See analysis 6, Table 75.)

Sumter.—A well owned by H. J. Webb, one-half mile south of Sumter, is 308 feet deep. The principal water-bearing bed is reported to be at the bottom, and the water stands within 26 feet of the surface. The water is described as clear "with a little sulphur," and is used for general domestic and farm purposes.

Huguenin.—Wells at Huguenin are described by McCallie [1] as follows:

> The Huguenin wells, located on the Huguenin plantation near Flint River, in the extreme southeastern part of Sumter County, are several in number, but only one furnishes a flow. Mr. J. M. Johnson, of Macon, Ga., the present owner of the Huguenin plantation, states that the flowing well on his property is located at Huguenin station, 1 mile west of Flint River. This well is 4 inches in diameter and 167 feet deep; it flows 10 gallons a minute. Mr. Johnson reports six or seven other wells on the property varying from 75 to 220 feet in depth, but they are all located on high ground and are nonflowing.

Andersonville.—A well near Andersonville is described by McCallie [1] as follows:

> The Andersonville well, which is located on A. F. Hodges's farm, near Andersonville, is 244 feet deep and 3 inches in diameter. The water rises to within 132 feet of the surface. The well is cased to a depth of 200 feet and is supplied with a deep-well pump, operated by a windmill. The water, which is said to be wholesome, is used for general domestic and farm purposes. Mr. Hodges was unable to give a complete record of the well, but he states that a thick bed of kaolin was penetrated at a depth of perhaps 100 feet from the surface.

A spring of both historic and scientific interest is located at the site of Andersonville prison. It illustrates one of the ways in which springs originate, for it was formed during the Civil War, while the prison was in use, by a heavy rain which washed a gully on one of the slopes within the stockade deep enough to intersect a water-bearing stratum.

Old Danville.—The well near Old Danville is described by McCallie [1] as follows:

> Mr. C. S. S. Horne's well, located near Old Danville, was completed in 1900. The well is 3 inches in diameter and 355 feet deep. The water, which rises to within 90 feet of the surface, is said to come from a porous rock, first struck at about 300 feet. The static head of the water is lowered by long-continued pumping. The well is cased to hard rock at 114 feet.

Leslie.—Wells at Leslie are described by McCallie [2] as follows:

> Leslie has several bored wells, varying from 100 to 125 feet in depth. These wells are all small and are reported to have struck hard rock at 50 feet. The water rises to

[1] Georgia Geol. Survey Bull. 15, p. 169, 1908. [2] Idem, p. 170.

points varying from 14 to 40 feet from the surface, depending upon the location of the well. Long pumping is said to lower the static head of the water. The water-bearing stratum is sand which occurs near the bottom of the well.

TABLE 74.—*Wells in Sumter County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Americus, No. 1	City		Otto Veatch		360
2	Americus, No. 2	do		do		360
3	Americus, No. 3	do		do		360
4	Americus, No. 4	do		do	1907?	360
5	Americus	Windsor Hotel		S. W. McCallie[a]	1883	360
6	Americus (public square).	City		L. G. Council		360
7	Americus	Central of Georgia Ry.		S. W. McCallie[a]		348
8	Americus, 1½ miles north of.	E. C. Speer		do		
9	Americus, 2½ miles southeast of.	Perry & Brown		do		
10	Americus, 5 miles southeast of.	T. B. Hooks	Wm. Brewer	T. B. Hooks	1907	
11	Americus, 1½ miles south of.	Peter F. Bahnsen	J. J. James, Sumter.	Owner	1912	
12	Andersonville (near).	A. F. Hodges		S. W. McCallie[a]		394
13	Huguenin, 1 mile west of Flint River.			J. M. Johnson[a]		
14	Leslie			Mayor		
15	Old Danville (Flint River).	C. S. S. Horne		S. W. McCallie[a]	1900	
16	Plains	Town	James Edwards.	T J. James	1910	
17	do	J. D. Clark and T. J. Spann.				
18	Sumter, ½ mile south of.	H. J. Webb	M. N. Brewer, Dawson.	H. J. Webb	1906	

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	337				65				See Table 75, analysis 1.
2	450?				60				Slightly hard.
3	700±							Flows	Hard.
4	992	10	962–992	(b)	60				Hard; see Table 75, analysis 2.
5	1,725	4	1,000		30				
6	900?								
7	480							Flows	
8	212	4			102				
9	284	4	284	100	100			Windmill, deep-well pump.	Ferruginous and sulphurous.
10	450	4	340		40			Gasoline engine	Hard.
11	180	5	177–180	40–60	80			Electric motor	See Table 75, analysis 4.
12	244	3			132			Windmill, deep-well pump.	
13	167	4				10		Flows	
14	160				15		10	Force pump	Hard. Several wells.
15	355	3	300–355		90				
16	244	3	243	150	85		10	Gasoline engine, deep-well pump.	Hard, ferruginous.
17	265			240–265					See Table 75, analysis 5.
18	308	2	308		26			Windmill	Soft.

[a] Georgia Geol. Survey Bull. 15, pp. 166–169, 1908.

[b] See log, p. 394.

TABLE 74.—*Wells in Sumter County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Municipal supply.	Ripley formation..	.....	Cased to 245 feet.
2	.....do.....	Ripley formation?	.....	
3	.....do.....	Upper Cretaceous.	.....	
4	.....do.....	Cretaceous.....	.....	10-inch casing to 226 feet; 8-inch casing to 402 feet; 6-inch casing to 962 feet. See logs, pp. 394–395.
5	.....	.....	.....	Abandoned.
6	.....	Cretaceous?.....	.....	
7	Boilers of locomotives.	Ripley formation..	.....	
8	Domestic, boiler supply.	Eocene?.....		
9	Domestic.....	Eocene or Ripley formation.	Cavity in rock....	
10	.....do.....	.....do.....	Sand.....	Cost of well, $480.
11	Drinking.....	Jackson formation?	Cavity below rock.	5-inch casing to 125 feet. See log, p. 396.
12	Domestic and farm	Ripley formation?	.....	3-inch casing to 200 feet.
13	.....	Eocene.....	.....	Also 6 or 7 nonflowing wells 75 to 220 feet deep.
14	Domestic, manufacturing.	Vicksburg formation?	Sand	
15	Domestic.....	Eocene?.....	Porous rock.....	Water lowered by pumping; 3-inch casing to 114 feet.
16	.....do.....	Midway formation?	Cavity with some sand.	Cost of well, $268; 2-inch casing to 185 feet. See log, p. 397.
17	.....	.....do.....	Thin layer of rock.	
18	Domestic.....	Eocene?.....	.....	2-inch casing to 285 feet. Cost of well, $350.

TABLE 75.—*Analyses of underground waters from Sumter County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	Apr. 19, 1911	City well No. 1..	Americus.....	Ripley formation.	337	Edgar Everhart.
2	.....do.....	City well No. 4..	.....do.....	Cretaceous.....	962–992	Do.
3	.....do.....	Springs (part of municipal supply).	.....do.....	Jackson formation?	.....	Do.
4	Dec. 16, 1912	Well of Peter F. Bahnsen.	Americus, 1½ miles south of.	.....do.....	177–180	Do.
5	Apr. 20, 1911	Well of J. D. Clark and T. J. Spann.	Plains.....	Midway formation?	240–265	Do.
6	.....do.....	Magnolia Spring.	Plains, 3½ miles north of.	Wilcox formation.	.....	Do.

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na + K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Remarks.
1	16	0.4	46	2.0	5.0	0.0	171	Tr.	Tr.	3.5	170	Well 1, Table 74.
2	25	1.0	49	5.0	10	2.0	171	12	0.3	3.0	200	Well 4, Table 74.
3	17	.6	2.0	1.0	5.0	.0	17	Tr.	Tr.	3.0	50	
4	34	10	32	9.0	16	.0	176	13	.0	4.0	209	Well 11, Table 74.
5	27	3.0	34	3.0	8.0	.0	134	6.0	1.5	3.5	179	Well 17, Table 74.
6	30	4.5	46	5.0	6.4	.0	171	10	1.0	2.5	212	See pp. 397–398.

TALBOT COUNTY.

GENERAL FEATURES.

Talbot County is in the western part of Georgia on the border between the Piedmont Plateau and the Gulf Coastal Plain. Its area is 312 square miles and its population (census of 1910) is 11,696. Agriculture is the chief industry.

TOPOGRAPHY.

A small tract in the southern part of the county, less than one-fourth of the total area, is included within the physiographic division known as the fall-line hills. The remainder lies within the Piedmont Plateau.

The Coastal Plain area is hilly and the hills are more or less smoothly rounded in outline with a probable maximum topographic relief of 300 to 350 feet. The existing topography has resulted from the dissection of the northernmost border of the Coastal Plain upland. Much of the surface is blanketed with loose gray residual or slightly wind-shifted or torrent-shifted sand. Drainage is through the headwater streams of Upatoi Creek, a tributary of Chattahoochee River, and the headwater streams of Whitewater Creek, a tributary of Flint River.

GEOLOGY.

Lower Cretaceous deposits are the only sediments of the Coastal Plain represented. They appear in a belt of country 3 to 6 miles wide along the southern border of the county and consist of irregularly bedded coarse arkosic sands, with subordinate lenses of light-colored massive clays. They rest upon the southward-sloping surface of crystalline basement rocks and attain an estimated thickness of 300 or 400 feet. (See Pl. III, p. 52.)

In texture, composition, and structure the Lower Cretaceous deposits are admirably suited to carry waters of excellent quality, though they probably contain them in only moderate quantities.

WATER RESOURCES.

In the Coastal Plain area nearly all water for domestic use is obtained from dug wells, which so far as reported do not exceed 70 feet in depth, and from small springs. The source of the water is the Lower Cretaceous deposits.

The waters from most wells and springs are soft and contain only small amounts of dissolved mineral matter. Locally they are more or less ferruginous and sulphurous.

The log of a well one-half mile east of Geneva, the lithology of which is furnished by the owner, J. F. Downs, shows 50 feet of hard red gravel with some "chalk" (white clay) and some sand, water bearing in lower 5 feet.

Small headwater streams furnish an abundance of excellent water for stock and for steam production.

In the southern part of the county moderate quantities of soft water are obtainable at depths of 100 to 300 feet from beds of sand in the Lower Cretaceous deposits.

TATTNALL COUNTY.

GENERAL FEATURES.

Tattnall County is in the southeastern part of the Coastal Plain of Georgia, its southeastern boundary being about 50 miles from the Atlantic coast. Its area is 642 square miles and its population is 18,569 (census of 1910). Agriculture and the production of lumber and naval stores are the chief industries.

TOPOGRAPHY.

The surface of the upland is rolling to hilly in the north and gently rolling to nearly level in the south. Its elevation above sea level is estimated to be 175 to 250 feet. Altamaha River, which forms the southwestern boundary, has cut its gradient down to less than 75 feet above sea level and is bordered by two relatively narrow Pleistocene terrace plains, one lying 10 to 15 feet and the other 40 to 50 feet above low-water level.

The small streams which drain the county flow sluggishly through shallow valleys and in many places are bordered by swamps. In the south cypress ponds, gum ponds, and bays are common.

GEOLOGY.

The Alum Bluff formation (of Oligocene age), which consists of 100 feet or more of sands and bluish or whitish clays, locally indurated, outcrops in the valleys of Altamaha and Ohoopee rivers, and underlies the remainder of the county beneath undifferentiated younger deposits.

The Alum Bluff formation is overlain by 100 or 150 feet of irregularly bedded, locally indurated coarse sands with sandy clays, which are mapped as of undifferentiated Oligocene to Pleistocene age. These surficial materials are the source of the water obtained in shallow wells.

Pleistocene terrace deposits have been laid down in small areas along Altamaha River.

The Alum Bluff formation is underlain by the Vicksburg formation, which contains water-bearing beds. At Claxton, according to a set of borings obtained from a well owned by N. H. Thaggard (see p. 404), limestones, in part water bearing, were encountered between the depths 365 and 550 feet. Fossil Bryozoa were obtained from the borings, which R. S. Bassler says are related to the bryozoan fauna obtained from upper Jackson (Eocene) strata at Wilmington, N. C., but may indicate either the Jackson or Vicksburg age of the containing strata. On the evidence of the contained Nummulites, T. W. Vaughan correlates this portion of the section with the Vicksburg formation.

The Vicksburg formation is underlain by undifferentiated deposits of Eocene and Cretaceous age, which at an unknown depth, perhaps 2,500 feet or more, are believed to rest upon a basement of ancient crystalline rocks.

Both the Eocene and Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug and driven wells 15 to 30 feet deep are the chief sources of domestic water supply. These wells yield soft waters, which if properly protected from surface pollution are wholesome. Artesian wells have been drilled at Reidsville, Claxton, Collins, Hagan, and Manassas. Small seepage springs are numerous but unimportant. The water of streams is used for stock, for the boilers of railway locomotives, and for steam production at sawmills.

Artesian water can be obtained anywhere in the county at depths of 100 to 1,500 feet or more. At most places supplies sufficient for general domestic purposes can be obtained from the Alum Bluff formation at depths less than 200 feet and are apt to be softer than those from the underlying Tertiary limestones. Flowing wells can probably be obtained in the valleys of the larger streams.

LOCAL SUPPLIES.

Reidsville (population 454, census of 1910).—The town of Reidsville owns a public water-supply system which obtains water from an artesian well 275 feet deep. The well is 6 inches in diameter and yields 40 gallons per minute by pumping. The water, which is probably derived from the Alum Bluff formation, rises to within 60 feet of the surface.

A sample from this well, collected February 14, 1913, was analyzed by Edgar Everhart as follows:

The log of a well one-half mile east of Geneva, the lithology of which is furnished by the owner, J. F. Downs, shows 50 feet of hard red gravel with some "chalk" (white clay) and some sand, water bearing in lower 5 feet.

Small headwater streams furnish an abundance of excellent water for stock and for steam production.

In the southern part of the county moderate quantities of soft water are obtainable at depths of 100 to 300 feet from beds of sand in the Lower Cretaceous deposits.

TATTNALL COUNTY.

GENERAL FEATURES.

Tattnall County is in the southeastern part of the Coastal Plain of Georgia, its southeastern boundary being about 50 miles from the Atlantic coast. Its area is 642 square miles and its population is 18,569 (census of 1910). Agriculture and the production of lumber and naval stores are the chief industries.

TOPOGRAPHY.

The surface of the upland is rolling to hilly in the north and gently rolling to nearly level in the south. Its elevation above sea level is estimated to be 175 to 250 feet. Altamaha River, which forms the southwestern boundary, has cut its gradient down to less than 75 feet above sea level and is bordered by two relatively narrow Pleistocene terrace plains, one lying 10 to 15 feet and the other 40 to 50 feet above low-water level.

The small streams which drain the county flow sluggishly through shallow valleys and in many places are bordered by swamps. In the south cypress ponds, gum ponds, and bays are common.

GEOLOGY.

The Alum Bluff formation (of Oligocene age), which consists of 100 feet or more of sands and bluish or whitish clays, locally indurated, outcrops in the valleys of Altamaha and Ohoopee rivers, and underlies the remainder of the county beneath undifferentiated younger deposits.

The Alum Bluff formation is overlain by 100 or 150 feet of irregularly bedded, locally indurated coarse sands with sandy clays, which are mapped as of undifferentiated Oligocene to Pleistocene age. These surficial materials are the source of the water obtained in shallow wells.

Pleistocene terrace deposits have been laid down in small areas along Altamaha River.

The Alum Bluff formation is underlain by the Vicksburg formation, which contains water-bearing beds. At Claxton, according to a set of borings obtained from a well owned by N. H. Thaggard (see p. 404), limestones, in part water bearing, were encountered between the depths 365 and 550 feet. Fossil Bryozoa were obtained from the borings, which R. S. Bassler says are related to the bryozoan fauna obtained from upper Jackson (Eocene) strata at Wilmington, N. C., but may indicate either the Jackson or Vicksburg age of the containing strata. On the evidence of the contained Nummulites, T. W. Vaughan correlates this portion of the section with the Vicksburg formation.

The Vicksburg formation is underlain by undifferentiated deposits of Eocene and Cretaceous age, which at an unknown depth, perhaps 2,500 feet or more, are believed to rest upon a basement of ancient crystalline rocks.

Both the Eocene and Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug and driven wells 15 to 30 feet deep are the chief sources of domestic water supply. These wells yield soft waters, which if properly protected from surface pollution are wholesome. Artesian wells have been drilled at Reidsville, Claxton, Collins, Hagan, and Manassas. Small seepage springs are numerous but unimportant. The water of streams is used for stock, for the boilers of railway locomotives, and for steam production at sawmills.

Artesian water can be obtained anywhere in the county at depths of 100 to 1,500 feet or more. At most places supplies sufficient for general domestic purposes can be obtained from the Alum Bluff formation at depths less than 200 feet and are apt to be softer than those from the underlying Tertiary limestones. Flowing wells can probably be obtained in the valleys of the larger streams.

LOCAL SUPPLIES.

Reidsville (population 454, census of 1910).—The town of Reidsville owns a public water-supply system which obtains water from an artesian well 275 feet deep. The well is 6 inches in diameter and yields 40 gallons per minute by pumping. The water, which is probably derived from the Alum Bluff formation, rises to within 60 feet of the surface.

A sample from this well, collected February 14, 1913, was analyzed by Edgar Everhart as follows:

Analysis of water from the 275-foot town well at Reidsville.

	Parts per million.
Silica (SiO_2)	72
Iron (Fe)	5.0
Calcium (Ca)	13
Magnesium (Mg)	7.0
Sodium and potassium (Na+K)	12
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	86
Sulphate radicle (SO_4)	11
Nitrate radicle (NO_3)	Trace.
Chlorine (Cl)	4.0
Total dissolved solids	165

Claxton (population 1,008, census of 1910).—At Claxton water for domestic use is obtained chiefly from shallow dug and bored wells. The following log of an artesian well owned by N. H. Thaggard, completed in 1905, has been adapted from a published log by Fuller and Sanford.[1]

Log of well of N. H. Thaggard, Claxton.

[Samples received from the Hughes Specialty Well Drilling Co., Charleston, S. C.; United States Geological Survey well No. 589.]

	Thickness.	Depth.
	Feet.	*Feet.*
Orange and red pebbly sand with ferruginous nodules	3	3
Stiff red clay	7	10
Fine white sand, water bearing, with a little white clay	50	60
Soft "shell formation"	10	70
Brownish-gray sandy marl	50	120
Stiff blue marl	25	145
Tough gray rock	10	155
Gray sandy marl (probably gray sandy clay)	20	175
Very hard gray rock	5	180
Soft blue marl	40	220
Very hard rock	5	225
Tough marl	25	250
Very hard rock	20	270
Brownish-gray sandy marl	40	310
Hard white rock	40	350
Fine white sand	15	365
Hard brownish limestone; contains Nummulites sp. (numerous), Orbitoides sp. (cf. *O. stellata*), and Orbitoides sp	5	370
Hard brownish-gray marl	10	380
Hard gray rock	20	400
Marl and rock	52	452
Hard rock	8	460
Soft "shell formation"; contains Nummulites and Orbitoides; water bearing	45	505
Hard brownish limestone and dark-gray shale; contains Nummulites and Orbitoides	5	510
Brownish limestone with soft layers; contains Nummulites and Orbitoides; water bearing	36.5	546.5

Diameter of well, 8 inches; length of casing, 452 feet; water stands 80 feet below surface. Well yields 3 gallons per minute for each foot; head is depressed. Present yield, 100 gallons per minute. Temperature, 75° F.

The well penetrates the late Oligocene (?) beds and the Alum Bluff and Vicksburg formations. A partial set of borings, on file in the office of the United States Geological Survey (well No. 589), show that the well reached a depth of 550 instead of 546.5 feet. From borings in this set between 365 and 550 feet specimens of fossil Bryozoa were obtained, which R. S. Bassler says are related to the

[1] Fuller, M. L., and Sanford, Samuel, Record of deep-well drilling for 1905: U. S. Geol. Survey Bull. 298, pp. 201, 202, 1906.

bryozoan fauna of Jackson age obtained from limestones at Wilmington, N. C., but may indicate either the Jackson or Vicksburg age of the containing strata. The specimens of Nummulites and Orbitoides indicated in the log were identified by J. A. Cushman. According to T. W. Vaughan, the presence of Nummulites probably indicates the Vicksburg age of the strata between 365 and 550 feet.

Collins (population 327, census of 1910).—At Collins water is obtained chiefly from shallow dug and driven wells. Two artesian wells have been reported, one 180 and the other 800 feet deep. In the 800-foot well, according to McCallie,[1] the water rises to within 142 feet of the surface and is reported to come from a water-bearing stratum near the bottom of the well.

The following log of the 180-foot well, which is owned by the Pine Product Co., has been prepared from a set of well borings on file in the office of the United States Geological Survey (well No. 213):

Log of well of the Pine Product Co., Collins.

[Samples sent by W. F. Hamilton.]

	Thickness.	Depth.
	Feet.	*Feet.*
Dark purplish, rather coarse argillaceous sand	2	2
Light-brown, rather coarse argillaceous sand	12	14
Pink-tinted coarse argillaceous sand, slightly indurated	22	36
Light-red coarse, slightly argillaceous, slightly indurated sand	6	42
Pink-tinted coarse loose sand	18	60
Light-gray coarse loose sand	35	95
Chunks of gray and pink-tinted coarse argillaceous, slightly indurated sand	16	111
Light-gray coarse loose sand	22	133
White sandy clay or kaolin	17	150
White clay or kaolin	30	180

The well penetrates late Oligocene? beds and a portion of the Alum Bluff formation.

Other localities.—McCallie[2] gives the following data on wells at Hagan and Manassas:

The Hagan well, put down by the Perkins Lumber Co. in 1900, is 3 inches in diameter and 447 feet deep. The water rises to within 60 feet of the surface. Water-bearing strata are reported at 230 and 447 feet. The following is a partial section of the well:

[*Log of well of Perkins Lumber Co., at Hagan.*]

	Feet.
Grayish sand	0– 20
Reddish sandstone	20– 28
White pipe clay and sand	28–120
Blue marl and sand	120–230

The Manassas well, owned by Mrs. M. F. Cummings, was completed in 1895, at a cost of $450. It is 6 inches in diameter and 480 feet deep. The water rises to within 109 feet of the surface. Three or four water-bearing strata are reported, the main supply of water coming from near the bottom of the well.

[1] Georgia Geol. Survey Bull. 15, p. 170, 1908. [2] Idem, p. 171.

TABLE 76.—*Wells in Tattnall County.*

No.	Location.	Owner.	Driller.	Authority.
1	Claxton	N. H. Thaggard	Hughes Specialty Well Drilling Co., Charleston, S. C.	Drillers.[a]
2	Collins	Pine Product Co.	B. Z. Mathews	W. F. Hamilton.
3	do	Town		S. W. McCallie.[b]
4	Hagan	Perkins Lumber Co.		Do.
5	Manassas	M. F. Cummings		Do.
6	Reidsville	Town		H. H. Elders, mayor.

No.	Date completed.	Approximate elevation above sea level.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute by pumping.	How obtained.
		Feet.	*Feet.*	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	
1	1905		546½	8	460–505	510–546½	80	100	
2	1905	238	180						
3		238	800	8			142		
4	1900		447	3		230, 447	60		
5	1895	217	480	6	480		109		
6	1906		275	6	275		60	40	Steam-engine air-lift pump.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1		Vicksburg formation.	Shell marl	The depth according to well borings at U. S. Geol. Survey (No. 589) is 550 feet. See log, p. 404.
2		Alum Bluff formation.		See log, p. 405.
3		Eocene?		
4		Vicksburg formation.		Do.
5		do		
6	Municipal supply.	Alum Bluff formation.		Cost of well, $500; of pump, $300. See analysis, p. 404.

[a] U. S. Geol. Survey Bull. 298, pp. 201, 202, 1906.
[b] Georgia Geol. Survey Bull. 15, pp. 170–171, 1908.

TAYLOR COUNTY.

GENERAL FEATURES.

Taylor County is in the west-central part of Georgia on the border between the Piedmont Plateau and the Gulf Coastal Plain. Its area is 340 square miles and its population (census of 1910) is 10,839. The chief industry is agriculture.

TOPOGRAPHY.

The northern part of the county, embracing somewhat less than half the total area, is included in the Piedmont Plateau, and the remainder, from a few miles north of the Central of Georgia Railway southward, lies within the Coastal Plain.

The county is drained by Flint River through its tributaries, White Water, Patsiliga, and smaller creeks. The surface of the Coastal Plain is hilly, the existing topography having resulted from the dissection of an upland plain. The maximum topographic relief is probably between 325 and 350 feet. The area forms a part of the physiographic division known as the fall-line hills. In general, the hills have rounded outlines, and their tops and slopes are blanketed by a nearly universal covering of residual though more or less wind-shifted or torrent-shifted sand.

GEOLOGY.

The surface of the crystalline rocks which outcrop in the Piedmont Plateau area slopes southward beneath the deposits of the Coastal Plain. The latter deposits are all of Cretaceous age. Lower Cretaceous deposits, which consist of 500 or 600 feet of coarse, irregularly bedded arkosic sands with subordinate lenses of light-colored massive clays, rest upon the crystalline rocks, and appear at the surface in a belt several miles wide extending east and west through the center of the county. These are unconformably overlain by Upper Cretaceous sands and clays of shallow-water origin, which appear at the surface over the remainder of the county south of the belt of outcrop of the Lower Cretaceous deposits. The Upper Cretaceous strata belong to the Ripley formation and chiefly to the Cusseta sand member of that formation. In the western part of the county it is believed that representatives of the Eutaw formation of the Upper Cretaceous intervene between the Lower Cretaceous deposits and the Cusseta sand, but these have not been accurately differentiated. The combined thickness of the Upper Cretaceous sediments within the county is probably 500 or 600 feet. (See Pl. III, p. 52.)

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

In the Coastal Plain section water for domestic purposes is obtained chiefly from dug wells 15 to 160 feet deep and from springs. The waters are generally of good quality except where contaminated from local surface sources. The wells tap water-bearing beds in strata of Lower Cretaceous or Upper Cretaceous age.

The springs are usually small but where conveniently located afford waters of satisfactory quality for domestic purposes. The largest spring reported, which yields 28 gallons per minute, is a mile north of Reynolds and is owned by G. T. Ruffin, of Reynolds. The water has been piped to Reynolds and is used in boilers by several small factories and by a few families.

Spring waters are utilized for steam production at a few small sawmills and gristmills. At several sawmills the combined flow from several closely adjoining springs is used to operate small water-power plants.

Small creeks and headwater branches afford abundant supplies of excellent water for stock and for steam production.

The Cretaceous beds outcropping in the southern part of the county, which include representatives of both the Lower and Upper Cretaceous, are favorable physically to the retention of large quantities of water. Prospects for obtaining artesian water supplies from these sources at reasonable depths are good at all points south of the Central of Georgia Railway.

It may be possible to obtain flowing wells at the lowest levels of the valleys of Whitewater and Cedar creeks in the extreme southern part of the county, but elsewhere flows are scarcely to be expected.

LOCAL SUPPLIES.

Reynolds (population 521, census of 1910).—McCallie[1] has published the following partial section and description of the materials penetrated in a well (No. 8, Table 77) drilled to a depth of 700 feet at Reynolds:

Partial log of well of Central of Georgia Railway at Reynolds (No. 8, Table 77).

	Thickness.	Depth.
	Feet.	*Feet.*
Yellow sand	6	6
Variegated clay	25	31
Sand	3	34
White clay	3	37
Coarse gravel	4	41
Reddish sand	3	44
White clay	18	62
Yellow sand	14	76

At 600 feet a hard dark-colored rock is reported, which extends to the bottom of the well. This hard stratum is probably the crystalline rock which outcrops along Flint River about 7 miles north of Reynolds. The water from the 75-foot water-bearing stratum is said to be quite soft. It is used by the Central of Georgia Railway for steam purposes.

The strata described in the log are of Lower Cretaceous age.

The log of a dug well (No. 9, Table 77) owned by A. J. Crawford, with lithologic descriptions furnished by the owner, is as follows:

[1] Georgia Geol. Survey Bull. 15, pp. 171-172, 1908.

Log of well of A. J. Crawford, 600 yards southeast of the post office at Reynolds (No. 9, Table 77).

	Thickness.	Depth.
Lower Cretaceous:	*Feet.*	*Feet.*
Sandy soil	4	4
Clay	7	11
"Chalk" (white clay) and clay	12	23
Coarse sand with some water at base	10	33
Alternating layers of clay, rock, and mud, furnishing a small amount of water at base	47	80

Other localities.—Detailed information concerning several of the deeper dug and bored wells is given in Table 77 (Nos. 1 to 7, 9, and 10). The logs of three of these wells follow:

Log of well of J. L. Whitley, 1½ miles north of Mauk (No. 7, Table 77).

[The owner is authority for the lithology.]

	Thickness.	Depth.
Upper Cretaceous:		
Ripley formation (Cusseta sand member):	*Feet.*	*Feet.*
Sand	8	8
Clay	5	13
Sand	25	38
"Chalk" (clay)	4	42
Sand	18	60
Eutaw formation (?):		
Black marly "chalk" (clay)	13	73
Formation (?):		
"Chalk" (clay) and sand, water bearing in basal 2 feet	52	125

Log of well of George Ruffin, 1½ miles east of Mauk (No. 6, Table 77).

[Authority for the lithology, J. A. Steed, Mauk.]

Upper Cretaceous, Ripley formation, Cusseta sand member:	Feet.
Clay	?
Sand	?
"Chalk" [clay] and sand	?
Coarse sand	?
White pebble rock	?
	90

Log of well of W. G. Hill, three-eighths of a mile north of Southland (No. 10, Table 77).

[The owner is authority for the lithology.]

	Thickness.	Depth.
Upper Cretaceous, Ripley formation, Cusseta sand member:	*Feet.*	*Feet.*
Sand	3	3
"Chalk" (white clay) and clay	9	12
Fine sand of various colors, water bearing in lower 2 feet	63	75

TABLE 77.—*Wells in Taylor County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Butler	M. T. Chapman		J. W. Riley, Butler.		650?
2	Charing	J. T. Garrett		Owner	1906	(*a*)
3	Charing, ¼ mile north of.	T. C. Bloodworth	J. B. Watson (deceased).	H. H. Rogers, Charing.	1909	(*b*)
4	Charing, 1¾ miles northwest of.	Walton Watson	Orange Howell, Paschal.	Owner		(*a*)
5	Mauk, ½ mile northeast of.	W. A. Woodall		C. E. Wall, Mauk.		(*c*)
6	Mauk, 1½ miles east of.	George Ruffin		J. A. Steed, Mauk.	1885	
7	Mauk, 1½ miles north of.	J. L. Whitley		Owner	1910	(*d*)
8	Reynolds	Central of Georgia Ry.		S. W. McCallie *e*		433
9	do	A. J. Crawford	Amos Turner, Reynolds.	Owner	1909	433
10	Southland, ¾ mile north of.	W. G. Hill		do	1906	(*f*)

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute by pumping.	How obtained.	Quality.
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*			
1	45	48	40			Small	Bucket and rope	Soft.
2	74	30	72	45–65		do	do	Do.
3	72	12	70		70	do	do	
4	160.5	36	160			do	do	Do.
5	80	48	80			do	do	
6	90	*g* 48 / *h* 36	60			do	Pumps	
7	125	*g* 36 / *h* 30	123	38	123	do	Bucket and rope	Do.
8	700	4		75, 250	75		Steam pump	Do.
9	80	30	33	80	79.5	Very small		
10	75	32	73		73	do		

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Boiler supply	Lower Cretaceous.	Sand	Dug.
2	Domestic	Cusseta sand		Dug. Cost, $50.
3	do	do	Sand	Bored. Cost, $19.
4	do	do		Dug.
5	do	do		Do.
6	do	do	Gravel and sand	Dug. Cost of well, $30; of pump, $22. See log, p. 409.
7	do	Cretaceous	Sand	Dug, cased part of way. Cost, $30. See log, p. 409.
8	Boiler supply	Lower Cretaceous.	do	Enlarged to 13 feet in diameter to 80 feet; walled with brick. See log, p. 408.
9		do	Coarse sand	Dug crooked and not used. Cost, $40. See log, p. 409.
10	Domestic	Ripley formation (Cusseta sand member).	Sand	Dug, cased part of way with wood. Cost, $30. See log, p. 409.

a On hill.
b On upland.
c On hill slope.
d Elevation same as Atlanta, Birmingham & Atlantic R. R. track at station.
e Georgia Geol. Survey Bull. 15, pp. 171, 172, 1908.
f Elevation 60 feet higher than Atlanta, Birmingham & Atlantic R. R. track at station.
g Diameter at top of well.
h Diameter at bottom of well.

TELFAIR COUNTY.

GENERAL FEATURES.

Telfair County is in the central part of the Coastal Plain of Georgia. McRae, the county seat, is on the Southern Railway 78 miles south of Macon. Ocmulgee River forms the southern boundary and Little Ocmulgee River or Gum Swamp the eastern boundary. The area of the county is 373 square miles and the population is 13,288 (census of 1910). Agriculture and the shipment of lumber and naval stores are the chief industries.

TOPOGRAPHY.

The upland is gently rolling to hilly. Streams are numerous, but their valleys are shallow, and the maximum surface relief probably does not exceed 150 feet. The county falls within the physiographic division called the Altamaha upland or wire-grass region. Ocmulgee River is bordered by two Pleistocene terrace plains, one a swamp about 15 feet above low-water level and the other a nearly level plain about 50 feet above the same datum. These plains are easily distinguished at Lumber City, the town being built upon the higher one. They are also fairly well developed along Little Ocmulgee River from its mouth upstream as far as Scotland.

The known altitudes above sea level at railroad stations are McRae, 229 feet; Scotland, 142 feet; Towns, 128 feet; Lumber City, 146 feet; and low water, Ocmulgee River at Southern Railway bridge, 94.5 feet.[1]

GEOLOGY.

The Alum Bluff formation (Oligocene), which consists of 100 feet or more of soft sandy clays and sands, in part water bearing, with interbedded thin layers of sandstone and quartzite, outcrops in the valleys of Ocmulgee River and its larger tributaries. One hundred feet or less of irregularly bedded sands and clays, probably of late Oligocene age, overlie the Alum Bluff formation and constitute the surface materials in the interstream areas. They weather to loose gray or yellow sands.

Pleistocene terrace deposits have been laid down in narrow areas bordering Ocmulgee River.

The Alum Bluff formation is underlain by 500 feet or more of limestones with interbedded layers of calcareous sandstone and marl which probably represent in descending order the Chattahoochee and Vicksburg formations of the Oligocene, and the Jackson formation of the Eocene. These formations contain water-bearing beds.

[1] Survey of Ocmulgee River, Ga., sheet 14: H. Doc. No. 215, 51st Cong.

Beneath the limestones in descending order are a series of sed ments of Eocene and Cretaceous age which probably have an aggr gate thickness of 1,500 feet or more and which rest upon a deepl buried basement of ancient crystalline rocks. These deposits co tain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The main sources of domestic water supply in the rural district are dug wells 10 to 50 feet deep, which penetrate the Pleistocen terrace deposits, the soft surficial sands and clays, and the Alu Bluff formation. These deposits yield soft waters in sufficient quan tities to supply the needs of the people except during times of unusu drought, when some of them fail.

Nonflowing artesian wells have been drilled at Helena and McRa and flowing wells at Lumber City, Towns, and Scotland. Sma seepage springs are fairly numerous, but most of them are of littl importance.

Artesian water can be obtained anywhere at depths of 100 to 1,00 feet or more. It is believed possible to obtain flowing wells in th valleys of the larger streams wherever the surface is not more tha 50 or 60 feet above low-water level. The areas of possible flo probably embrace only the terrace plains bordering Ocmulgee an Little Ocmulgee rivers, and the lowlands along the lower courses o Sugar and Horse creeks. (See Pl. XVIII, p. 122.) In most places i the county supplies sufficient for ordinary purposes can be obtaine at less than 500 feet. However, in view of the excellent qualit of water obtained in the 900-foot well at the McArthur planta tion, 5 miles east of Lumber City, it might be advisable to dri wells of comparable depth elsewhere in the county in the hope o encountering the same or similar water-bearing beds.

LOCAL SUPPLIES.

Helena (population 890, census of 1910).—Helena is in the north eastern part of the county at the junction of the Seaboard Air Lin and the Southern railways. Three artesian wells have been drille for the Helena ice factory, two for public wells, one for the Coca-Co Bottling Works, and one for the cotton ginnery. These wells rang in depth from 220 to 350 feet, and the water rises to within 70 o 75 feet of the surface. Sand, drab fine-grained clay (the "marl" of the well driller), and thin layers of hard rock are encountered t 350 feet. The yield of the wells is small. (See analyses 1 and 2 Table 79.)

McRae (population 1,160, census of 1910).—McRae has a public water-supply system, the source being an artesian well 287 feet deep. The water rises to within 70 feet of the surface. The well doubtless penetrates strata of the same age as those in the Helena wells.

Scotland.—Scotland is on a terrace plain bordering Little Ocmulgee River 142 feet above sea level and about 100 feet lower than Helena. Four flowing wells, ranging in depth from 140 to 196 feet, have been drilled, one owned by the town and three by individuals. The maximum static head is 26 feet above the surface. Clear, cool, and moderately hard but potable water is yielded by each of the wells. A mineral analysis of the water from a well 160 feet deep, owned by A. Graham, is given in Table 79 (analysis 4).

Towns.—Nine artesian wells, ranging in depth from 150 to 185 feet, drilled at or near Towns, tap water-bearing beds in the Alum Bluff formation. A well 185 feet deep, owned by the town, is located on a terrace plain bordering Little Ocmulgee River about a foot below the level of the track at the Southern Railway station. Water-bearing beds were encountered at depths of 65 and 185 feet, from which hard sulphurous water rises 30 feet above the surface.

Lumber City (population 1,195, census of 1910).—Lumber City is on a terrace plain 50 to 60 feet above low-water level of Ocmulgee River. The elevation at the Southern Railway station is 146 feet above sea level. The water supply of the town is derived mainly from artesian wells.

According to information furnished by J. F. Wooten, a well contractor of Lumber City, 22 flowing wells have been drilled at and near this place, which have an average depth of 425 feet and yield flows ranging from 10 to 80 gallons per minute, the maximum static head observed being 14 feet above the surface. The principal water-bearing bed is at 425 feet, but a bed yielding a flow lies at about 320 feet. Rock, probably limestone, is reported at a depth of 360 feet. Apparently the yield of the wells has not decreased.

McCallie[1] has published the following log of one of the wells at Lumber City:

Log of well at Lumber City.

	Thickness.	Depth.
	Feet.	*Feet.*
Top soil	4	4
Red clay	16	20
Coarse sand	10	30
Hard blue clay with a few layers of sandstone	220	250
Quicksand	100	350
Limestone with water-bearing seams from 380 to 430 feet; limestone containing fragments of marl	80	430

[1] Georgia Geol. Survey Bull. 15, p. 172, 1908.

An analysis of water from the town well is given in Table 79 (analysis 3).

The wells at Lumber City probably tap water-bearing beds belonging to either the Chattahoochee or the Vicksburg formation.

Shamrock Springs.—Shamrock Springs is a local resort on Little Ocmulgee River (or Gum Swamp Creek) 1½ miles east of Helena. The accommodations include a hotel and small cottages. Several small springs emerge from the base of a sand hill at the edge of the swamp Two flowing artesian wells on the edge of the swamp afford the chief water supply. According to unpublished notes of McCallie each well is 140 feet deep and has a static head of 12 feet above the surface; the combined yield of the wells is 150 gallons per minute. The water, which has reputed therapeutic properties, is a typical calcium carbonate water of moderate mineral content. An analysis is given in Table 79 (analysis 5).

TABLE 78.—*Wells in Telfair County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Helena	McRae Coca Cola Bottling Co.		H. F. Thaxton	1908	247
2	....do	Helena Ice Co.				
3	Lumber City	Town	J. F. Wootten	J. F. Wootten		146
4	McRae	....do		S. W. McCallie [a]		230
5	Towns	....do		J. M. Towns	1903	128
6	Scotland		J. F. Wootten	J. F. Wootten		142
7	....do	A. Graham				
8	Shamrock Springs, 1½ miles east of Helena.			S. W. McCallie [b]		
9	....do			....do [b]		

No.	Depth.	Diameter.	Depth to principal water bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	250	4	250	.....	−50	.....	8+	Force pump	Analysis 1, Table 79.
2	220	.....	.....	.....	.....	.....	.....	.....	Analysis 2, Table 79.
3	[c] 425	2½	425	320	+14	10+	.....	Flows	Analysis 3, Table 79.
4	287	4	287	200	−70	.....	.....	Force pump	
5	185	2	185	65	+30	60	.....	Flows	Hard.
6	[c] 195	2½	190	.....	+26	90	.....	....do	Do.
7	160	.....	.....	.....	.....	.....	.....	.....	Analysis 4, Table 79.
8	140	.....	.....	.....	+12	75?	.....	Flows	
9	140	.....	.....	.....	+12	75?	.....	....do	Analysis 5, Table 79.

[a] Georgia Geol. Survey Bull. 15, p. 172, 1908. [b] Unpublished notes. [c] Average.

TABLE 78.—*Wells in Telfair County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Bottling works	Oligocene?	Porous rock	Cost of well $250; cost of machinery, $100. Five other artesian wells.
2	Manufacture of ice.	do		Owns two other similar wells.
3	Domestic and boiler supply.	Chattahoochee or Vicksburg formation.	Porous limestone	21 other artesian wells have been drilled at or near Lumber City. Cost, $300 to $1,000. See log, p. 413.
4	Municipal supply.	Oligocene?		
5	Domestic and boiler supply.	Alum Bluff formation?	Rock and sand	Cost, $200. Diameter at top, 4 inches; at bottom, 2 inches; 8 other artesian wells have been drilled at Towns. Average depth, 175 feet. Average cost, about $300.
6	do	do	Rock	3 other artesian wells have been drilled; average cost, $300.
7		Oligocene		
8	Drinking	Alum Bluff formation?		
9	do	do		

TABLE 79.—*Analyses of underground waters from Telfair County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	Apr. 18, 1911	Well of McRae Coca Cola Bottling Co.	Helena	Oligocene?	250	Edgar Everhart.
2		Well of Helena Ice Co.	do	do	220	Dearborn Chemical Co.
3		Town well	Lumber City	Chattahoochee or Vicksburg formation.	425	Edgar Everhart.[a]
4	Apr. 17, 1911	Well of A. Graham.	Scotland	Oligocene	160	Do.
5	Nov., 1907	Flowing well	Shamrock Springs.	Alum Bluff formation?	140	Do.

No.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	44	2.0	.....	43	8.0	18		2.5	207	2.0	Tr.	10	.....	262	Well 1, Table 78.
2	30	1.3[b]	.....	46	8.0	11		78	.....	14	.....	18	4.0	210	Well 2, Table 78.
3	8.3	17[b]	.....	40	5.1	8.1	2.6	58	.....	30	.....	10	.....	180	Well 3, Table 78.
4	38	.4	.....	54	6.0	12		Tr.	246	2.0	0.5	8.0	.....	272	Well 7, Table 78.
5	43	.1	0.1	62	9.8	7.1	1.7	.....	221	4.7	.....	10	.....	251	Well 9, Table 78.

[a] Georgia Geol. Survey Bull. 15, pp. 172, 173, 1908.

[b] $Fe_2O_3 + Al_2O_3$.

TERRELL COUNTY.

GENERAL FEATURES.

Terrell County is in the western part of the Coastal Plain of Georgia. Dawson, the county seat, is at the intersection of the Seaboard Air Line and the Central of Georgia railways, 66 miles southeast of

Columbus and 98 miles southwest of Macon. The area of the county is 322 square miles and the population is 22,003 (census of 1910). Agriculture is the chief industry.

TOPOGRAPHY.

In the north the surface is rolling to hilly and the land well drained; the creeks and branches have cut their courses 100 to 150 feet below the divides. In the south the surface is slightly hilly to nearly level; the creeks are bordered by broad swamps, and lime sinks and cypress ponds are common.

The general upland surface lies 300 to 485 feet above sea level, the highest elevation being in the north. The known altitudes above sea level at railroad stations are Parrott, 482 feet; Dawson (Seaboard Air Line Railway), 376 feet; Dawson (Central of Georgia Railway), 326 feet; Sasser, 336 feet; Central of Georgia Railway bridge, Kinchafoonee Creek, 265 feet; and Central of Georgia Railway bridge, Ichawaynochaway Creek, 283 feet.

GEOLOGY.

Deposits of Eocene age outcrop in the valley of Ichawaynochaway Creek in the west and in the valley of Kinchafoonee Creek in the northeast, and underlie the remainder of the county beneath the younger (Oligocene) Vicksburg formation. The Eocene beds consist of several hundred feet of sands and clays locally indurated. They have not been accurately differentiated within the county, but it is believed that their basal portion represents the Midway formation, which does not appear at the surface within the county. The Wilcox formation probably overlies the Midway and appears at the surface in the valley of Ichawaynochaway Creek in the extreme west; the Wilcox is overlain by about 150 feet of strata believed to represent the Claiborne group. The Eocene deposits contain important water-bearing beds.

The Vicksburg formation, which consists of limestones with interbedded sandy layers, overlies the Eocene deposits and appears at the surface throughout the remainder of the county; the formation weathers to red argillaceous sands and sandy clays containing fragments and masses of flint. The thickness of the formation in the north is 50 to 100 feet, but southward it becomes thicker, reaching 200 or 250 feet along th esouthern border, where it becomes an important aquifer.

The Eocene deposits are underlain by 1,800 or 2,000 feet of sands, clays, and marls of Cretaceous age which do not appear at the surface within the county and which at an unknown depth, perhaps 2,000 or 2,500 feet, rest upon crystalline basement rocks. The Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug and bored wells 20 to 80 feet deep are the chief source of domestic water supply. Of the two types, the bored wells are preferable, for if properly cased they afford less opportunity for contamination from surface sources. The shallow wells yield small supplies and some of them fail during times of drought. Artesian wells have been drilled at Dawson, Graves station, Parrott, and Sasser. There are no large springs in the county, but in the north small springs are numerous and supply water for household use on small farms. The waters of streams are suitable for stock and boiler supply.

The prospects are good for obtaining artesian water anywhere in the county at depths of 100 to 1,500 feet or more, and it is probable that flowing wells can be obtained on the lower lands bordering Kinchafoonee, Ichawaynochaway, and Chickasawhatchee creeks.

LOCAL SUPPLIES.

Dawson (population 3,827, census of 1910).—The town of Dawson owns a water-supply system and obtains water from a deep well. C. D. Marshall and F. W. McNulty, of Dawson, have furnished the following information:

The well was drilled in 1903, is 447 feet deep, and is 8 inches in diameter at the bottom. The water rises within 36 feet of the surface and is lifted to the surface by means of an air-compressor pump at the rate of 500 gallons per minute. The water is used for general domestic and manufacturing purposes. (See analysis 1, Table 81.) The well described probably taps a water-bearing bed in the upper part of the Cretaceous deposits (Ripley formation).

Spencer[1] describes another well drilled by the town at an earlier date. The water, which rises nearly to the surface, is obtained by a hand pump and is used locally for drinking and domestic purposes. The depth to the principal water-bearing bed is not known, but the well probably enters the Ripley formation. (See analysis 2, Table 81.) Spencer gives the following log:

Log of old town well at Dawson.

	Thickness.	Depth.
	Feet.	*Feet.*
Clayey white sand	40	40
Coarse sand	40	80
Limestone, followed by sand and rock	570	650
Quicksand	10	660

[1] Georgia Geol. Survey First Rept. Progress, p. 79, 1891.

Parrott (population 360, census of 1910).—At Parrott water for domestic use is obtained chiefly from a well 300 feet deep, in which the water rises to within 65 feet of the surface. The daily consumption is about 8,000 gallons, and the supply is said to be satisfactory. A few shallow wells are in use.

Graves station.—Wells near Graves station have been described by McCallie [1] as follows:

> Two deep wells have been put down near Graves station, one by Mr. J. B. Graves and the other by Mr. W. D. Davidson. The former well is 3 inches in diameter and 321 feet deep. Water rises to within 50 feet of the surface. Several layers of hard rock, 20 feet thick, are reported in this well, and a marl bed at 150 feet. No data have been received concerning the Davidson well.

Sasser.—Wells in the vicinity of Sasser are described by McCallie [1] as follows:

> There are several nonflowing deep wells in the vicinity of Sasser. They vary from 214 to 540 feet in depth and furnish a copious supply of water, rising from 28 to 60 feet from the surface. Mr. M. N. Brewer, a well contractor, has kindly furnished the following record of Mr. J. H. Wooten's well, located 2 miles southwest of Sasser:

[*Log of well of J. H. Wooten, 2 miles southwest of Sasser* (*No. 7, Table 80*).]

	Feet.
Clay	0– 50
Red sand	50– 80
Limestone	80– 90
White sand, water bearing	90–120
Limestone	120–130
White clay	130–140
Limestone, with thin layers of flint	140–147
Fine white water-bearing sand	147–160
Hard rock, water bearing	160–165
Bluish sand	165–225
Limestone with thin layers of flint	225–260
Gray marl	260–300
Hard rock	300–303
White water-bearing sand	303–310
Limestone with layers of flint	310–340
Blue marl	340–428
Hard flint	428–431
Gray marl and white clay	431–504
Hard rock, water bearing	504–530

Another well, 7 miles east of Sasser, owned by Mr. J. M. King, attains a depth of only 214 feet. Water-bearing strata are reported in this well at 96, 150, and 214 feet, respectively. The water from the 214-foot stratum rises to within 28 feet of the surface.

[1] Georgia Geol. Survey Bull. 15, p. 175, 1908.

TABLE 80.—*Wells in Terrell County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Dawson			S. W. McCallie[a]		326
2	Dawson, ½ mile northeast of.	Town		C. D. Marshall and F. W. McNutty.	1903	326
3	Graves station	J. B. Graves		S. W. McCallie[a]		379?
4	Parrott	Town		Postmaster		
5	Sasser (several wells)			S. W. McCallie[a]		336
6	Sasser, 7 miles east of.	J. M. King		do.[a]		
7	Sasser, 2 miles southwest of.	J. H. Wooten	M. N. Brewer	do.[a]		

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	660				30			Hand pump	Hard; see analysis 2, Table 81.
2	447	8	447		36		500	Air-lift pump	See analysis 1, Table 81.
3	321	3			50				
4	300				65		12	Force pump	
5	214–540				28–60				
6	214		214	96, 150	28				
7	530		304–530	90 147 160 303					

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic, boiler supply.	Ripley formation?	Sand	9 other deep wells in vicinity. See log, p. 417.
2	Domestic, manufacturing.	do	Gravel	Diameter at top 10 inches and at bottom 8 inches. Cost of well, $1,000; machinery, $7,000.
3		Eocene		
4	Domestic	do		
5		do		
6		Tertiary		
7		Eocene? or Cretaceous?	Hard rock	See log, p. 418.

[a] Georgia Geol. Survey Bull. 15, pp. 173–175, 1908.

TABLE 81.—*Analyses of well waters from Terrell County.*

[Parts per million.

	1	2
Silica (SiO_2)	27	23
Iron (Fe)	.4	
Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$)		.6
Calcium (Ca)	39	43
Magnesium (Mg)	6.0	3.4
Sodium (Na)	14	7.6
Potassium (K)		1.4
Carbonate radicle (CO_3)	.0	
Bicarbonate radicle (HCO_3)	176	120
Sulphate radicle (SO_4)	12	24
Nitrate radicle (NO_3)	.4	
Chlorine (Cl)	3.0	8.2
Total dissolved solids	202	174

1. Well No. 2, Table 80; sample collected Mar. 29, 1911. Edgar Everhart, analyst.
2. Well No. 1, Table 80; Edgar Everhart, analyst: Georgia Geol. Survey Bull. 15, p. 174, 1908.

THOMAS COUNTY.

GENERAL FEATURES.

Thomas County is in the extreme southern part of the State in the tier of counties bordering Florida. Its area is 530 square miles and its population is 29,071 (census of 1910).

TOPOGRAPHY.

In the north the surface is nearly level to slightly undulating, the topographic aspect being somewhat similar to that of Colquitt, Tift, and other counties of the wire-grass section to the north and east; the broad interstream areas are poorly drained, and topographically the region is in a youthful stage of development.

In the south the relief is somewhat more pronounced than in the north, and lime sinks and lime-sink lakes and ponds are numerous; and the surface is more completely drained.

The streams are small and flow sluggishly. Their waters are dark from their high content of organic matter.

The maximum surface relief of the county probably does not exceed 100 or 125 feet. The known altitudes at railroad stations are Thomasville, 250 feet; Boston, 194 feet; Metcalf, 170 feet; Ochlockonee, 262 feet; and Meigs, 341 feet.

GEOLOGY.

The Chattahoochee formation (of Oligocene age), which consists of approximately 100 feet of cavernous, water-bearing limestones, underlies the entire county, but appears at the surface only in the valleys of Aucilla and Miccosukee rivers and in lime sinks in the south.

The Chattahoochee formation is overlain by 100 to 150 feet of sands and greenish or drab sandy clays belonging to the Alum Bluff

formation (also of Oligocene age) which outcrops in the valleys of Aucilla and Miccosukee rivers in the south and in the valley of Ochlockonee River along the northwestern boundary; this formation contains water-bearing beds.

Throughout the interstream areas of the county the Alum Bluff formation is overlain by irregularly bedded argillaceous sands and sandy clays, probably nowhere more than 75 feet thick, that are probably also of Oligocene age. These materials weather to loose gray residual sands which cover the surface to a depth of several feet.

The Chattahoochee formation is underlain by 200 feet or more of cavernous water-bearing limestones, which do not appear at the surface within the county and which belong to the Vicksburg formation of the Oligocene.

Beneath the Vicksburg formation in descending order lie strata of Eocene and Cretaceous age, probably aggregating 2,000 feet or more, the Cretaceous probably resting on a basement of ancient crystalline rocks. The Eocene and Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug wells 10 to 60 feet deep are the chief source of domestic water supply and furnish an abundance of water except during times of drought, when some of them fail. The waters of streams and ponds are soft and satisfactory for boiler supply, though they are highly colored by organic matter.

Deep wells have been drilled at Thomasville, Boston, Pavo, and Metcalf. (See Table 82.)

A few small springs scattered throughout the county yield pure waters in sufficient quantities for local domestic use. Allgood Spring,[1] the largest reported, is near Meigs in the northwestern part of the county and has a flow estimated at 100 gallons per minute.

Artesian water can be obtained anywhere at depths of 100 to 2,000 feet or more. The results of deep drilling seem to show that flowing wells can not be obtained, although it does not seem improbable that wells 1,000 feet or more in depth on the lowlands bordering the larger streams would flow. It would of course be necessary to case off the cavernous Oligocene and Eocene limestones, which would otherwise drain away the deeper-seated waters.

Wells tapping water-bearing beds in the cavernous limestones of the Chattahoochee formation are at certain places liable to contamination through lime sinks. Such wells should be sunk to greater depths and the casing extended below the limestone in order to prevent the entrance of questionable waters.

[1] Georgia Geol. Survey Bull. 15, p. 176, 1908.

LOCAL SUPPLIES.

Thomasville (population 6,727, census of 1910).—The municipal water supply of Thomasville is derived from three artesian wells. The water is hard but has proved satisfactory for general domestic purposes. (See analyses 2 and 3, Table 83.)

The following information regarding one of the city wells at Thomasville, drilled in 1907, was furnished to T. W. Vaughan by the driller, Mr. S. S. Chandler:

Log of city well at Thomasville.

	Thickness.	Depth.
	Feet.	*Feet.*
Sands and clays	80	80
Limestone containing flint	160	240
Gray sandy rock, moderately hard	204	444

The well furnishes 500 gallons of water per minute and stands at 175 feet below the surface. At 175 feet there is an underground channel that takes the water away.

J. W. Spencer [1] published the following partial log of one of the city wells at Thomasville, drilled about 1890:

Partial log of one of the city wells, Thomasville.

[Authority E. O. Thompson, superintendent of waterworks.]

	Feet.
Red and blue clay and sand to	162
Limestone to	225
Shell rock with water to	310
Rubble rock at	360
(From this level the water rises to within 210 feet of the surface.)	
Shell rock with copious flow at	410
Water at	1,400
Bottom of limestone	1,680
Quicksand thence to	1,820

This well probably penetrates all the Oligocene and Eocene deposits and enters the Cretaceous deposits.

The deep wells at Thomasville are believed to tap water-bearing beds in the Chattahoochee and Vicksburg formations.

Boston (population 1,130, census of 1910).—The municipal water supply of Boston is obtained from an artesian well 320 feet deep. Sandy water-bearing limestones were encountered at several levels between the depths 130 and 320 feet. The water rises to within 102 feet of the surface. The water-bearing bed is in either the Vicksburg or the Chattahoochee formation. (See analysis 1, Table 83.) The following log [2] was furnished to T. W. Vaughan by S. S. Chandler, the driller:

[1] Georgia Geol. Survey First Rept. Progress, p. 74, 1891.
[2] Georgia Geol. Survey Bull. 15, p. 180, 1908.

Log of town well at Boston.

	Thickness.	Depth.
	Feet.	*Feet.*
Yellow clay	90	90
Limestone with flint	40	130
Hard brown rock, water bearing	90	220
Hard brown rock	40	260
Soft brown rock	45	305
Hard brown rock	15	320

Pavo (population 572, census of 1910).—A well owned by Pavo, a town in the northeastern part of the county, is reported to be about 400 feet deep. The water, which rises to within about 200 feet of the surface, is considered hard, but is used for general domestic purposes and for boiler supply. The well probably penetrates the Chattahoochee and Vicksburg formations.

TABLE 82.—*Wells in Thomas County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Boston	Town	S. S. Chandler	S. S. Chandler and S. W. McCallie.[a]	.....	197
2	Metcalf	.....	.....	Postmaster	.....	170
3	Pavo	Town	W. F. Lloyd	W. M. Fambrough	1908	.....
4	Thomasville	....do	S. S. Chandler	S. S. Chandler	1907	258
5	....do	....do	.....	J. W. Spencer[b]	1890?	258

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*		*Galls.*		
1	320	6	130-320	.....	102	.....	50	.....	Hard; see analysis 1, Table 83.
2	225	.....	.....	.....	.....	.....	.....	Pump	
3	400±	6	.....	.....	200	.....	250	.....	Hard.
4	444	8	240-444	.....	175	.....	500	.....	
	1,820	.....	410	360-1,400	210	.....	.....	Air-lift pump	See analyses 2 and 3, Table 83.

[a] Georgia Geol. Survey Bull. No. 15, pp. 179-181, 1908.
[b] Georgia Geol. Survey First Rept. Progress, p. 74, 1891.

TABLE 82.—*Wells in Thomas County*—Continued.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Chattahoochee or Vicksburg formation.	Limestone	See log, p. 423.
2	Boiler supply, domestic.	do		
3	do	Vicksburg formation?	Limestone?	6-inch casing to 200± feet; cost of well, $700.
4	Municipal supply.	Chattahoochee or Vicksburg formation.	Sandy limestone	8-inch casing to 305 feet; see log, p. 422.
5		Vicksburg formation?	Limestone	See log, p. 422.

TABLE 83.—*Analyses of underground waters from Thomas County.*

[Parts per million.]

No.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.	Silica (SiO_2).	Oxides of iron and aluminum ($Fe_2O_3 + Al_2O_3$).
				Feet.			
1	Town well	Boston	Vicksburg formation?	320	Edgar Everhart [a]	20	18
2	Town well No. 1.	Thomasville	do	(?)	do [a]	20	1.6
3	Town well No. 2.	do	do	(?)	do [a]	20	1.4

No.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Phosphate radicle (PO_4).	Chlorine (Cl).	Total dissolved solids.	Free carbon dioxide (CO_2).	Remarks.
1	40	4.0	5.4	2.0	0.0	128	8.8	0.4	9.5	174	18	Well 1, Table 82.
2	48	22	9.0	2.6	.0	179	81	Tr.	12	278	4	Wells 4 and 5, Table 82.
3	48	22	7.8	2.1	.0	159	82	Tr.	12	274	20	Do.

[a] Georgia Geol. Survey Bull. 15, pp. 177–180, 1908.

TIFT COUNTY.

GENERAL FEATURES.

Tift County is in the south-central part of the Coastal Plain of Georgia in the long-leaf pine or wire-grass region. Tifton, the county seat, is 105 miles south of Macon. The area of the county is 243 square miles and the population is 11,487 (census of 1910). Lumber and naval stores are the chief products, but the pine timber is being rapidly exhausted and the inhabitants are giving increased attention to agriculture, which will doubtless be the chief industry in the near future.

TOPOGRAPHY.

The county is nearly level to moderately hilly. The upland portion lies 300 to 400 feet and the partly swampy lowlands along Little and Alapaha rivers somewhat less than 300 feet above sea level.

The streams are small and flow sluggishly through wide, dense swamps. The waters are free from silt or clay in suspension but are dark from their high content of organic matter. Little River, which flows south through the western part of the county, and Alapaha River, which forms a part of the northeastern boundary, are the principal streams.

GEOLOGY.

The Alum Bluff formation (of Oligocene age), which consists of 100 feet or more of greenish or drab sandy clays and sands interbedded with thin, hard layers, outcrops in a small area along Little River in the southwestern part of the county. The formation contains water-bearing beds and is overlain throughout the greater part of the county by 100 feet or less of mottled, irregularly bedded argillaceous sands, greenish sandy clays, and subordinate lenses of gravel, which are probably of Oligocene age. These materials weather to a sandy soil, which contains in places great numbers of small iron-oxide nodules and is locally known as "pebble" or "pimple" land. The deposits yield soft waters to shallow wells.

In a narrow belt on the east side of Little River accumulations of soft surficial sand form small sand hills of probable Pleistocene age.

The Alum Bluff formation is underlain by 400 or 500 feet of water-bearing limestones, which probably represent in descending order the Chattahoochee and Vicksburg formations of the Oligocene and the Jackson formation of the Eocene. These limestones are underlain in descending order by undifferentiated strata of Eocene and Cretaceous age, having an aggregate thickness of 2,000 feet or more. The Cretaceous probably rests upon a deeply buried surface of ancient crystalline rocks. The Eocene and Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Shallow dug wells are the chief source of domestic water supply Deep wells have been drilled at Tifton.

Streams and ponds are used locally for stock and are the principal source of boiler supplies for sawmills, factories, and railway locomotives. A few small springs on the edges of the creeks and swamps are used for domestic supplies. The water from the Murrow Mineral Spring, 4 miles west of Tifton, is bottled and sold for drinking (See Table 85, analysis 4.)

Artesian water can be obtained anywhere in the county at depths of 100 to 1,000 feet or more. It is doubtful if flowing wells can be obtained.

LOCAL SUPPLIES.

Tifton (population 2,381, census of 1910).—The town of Tifton owns a public water-supply system which obtains water from an artesian well 550 feet deep drilled in 1906. The water rises to within 125 feet of the surface, and the maximum yield by pumping is 420 gallons a minute. Rock is said to have been entered at 270 feet. The principal water-bearing bed is between 300 and 550 feet. The water has a slight odor of hydrogen sulphide and is moderately hard, but is used for general domestic and manufacturing purposes. (See analysis 1, Table 85.)

A partial set of well borings on file in the office of the United States Geological Survey (well No. 1174) probably came from the town well just described. The samples were furnished by the Hughes Specialty Well Drilling Co., of Charleston, S. C. The following partial log has been prepared:

Partial log of town well at Tifton.

	Thickness.	Depth.
	Feet.	*Feet.*
Missing	80	80
Mixture of clear quartz sand and fine fragments of claystone	20	100
White sandy claystone	20	120
Fine white sand	10	130
Chunks of light-gray flint showing dendritic growths	5	135
Missing	5	140
Fine light-gray argillaceous, calcareous sand	8	148
Very fine light-gray argillaceous, slightly calcareous sand	2	150
Mixture of coarse quartz sand and fragments of gray clay and white limestone	18	168
Missing	10	178
Very fine calcareous sand	7	185
Fine calcareous sand	15	200
Missing	12	212
White sandy limestone	66	278
Flint	5	283

The limestones penetrated between 212 and 278 feet probably belong to the Chattahoochee formation.

Another sample, bearing the well number 1,325, received in January, 1907, from the Hughes Specialty Well Drilling Co., was taken from the town well (probably the well just described) and is said to represent the materials penetrated between 298 and 400 feet. It consists of pure white limestone having a botryoidal appearance.

Capt. H. H. Tift's well, completed in 1896, is 368 feet deep and the water rises to within 125 feet of the surface. Two or three water-bearing strata are said to have been struck. Limestone was encountered at 260 feet. The principal water-bearing bed is sand, at a depth of 330 feet.

A well owned by the Tifton Ice & Power Co.,[1] near the Atlantic Coast Line Railroad station about 10 feet above the railroad track, is 572½ feet deep. The water, which rises to within 115 feet of the surface, is used chiefly for the manufacture of ice. The following is a partial log:

Partial log of well of Tifton Ice & Power Co., Tifton.

	Thickness.	Depth.
	Feet.	*Feet.*
Clay and sand	30	30
Sand rock	20	50
Rock and clay (20-foot layers)	100	150
Quicksand	25	175
Not reported	95	270
Hard flint	30	300
Porous limestone, containing water in caverns in lower 172 feet	212	512
Not reported	60.5	572.5

TABLE 84.—*Wells in Tift County.*

No.	Location.	Owner.	Authority.	Date completed.	Approximate elevation above sea level.
					Feet.
1	Tifton	Town	W. S. Walker	1906	370
2	do	H. H. Tift		1896	370
3	do	Tifton Ice & Power Co.	W. W. Burnham[1]		343?

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	550	8	300–550		125		420	Air-lift pump	Hard, slightly sulphurous. See analysis 1, Table 85.
2	368	8	330–368		125		150		Hard. See analysis 2, Table 85.
3	572½	6	340–512		115				Hard. See analysis 3, Table 85.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Municipal supply	Vicksburg formation?	Porous limestone	8-inch casing to 270 feet. Cost of well, $2,000; of machinery, $2,000. See log, p. 426.
2	Domestic	do	do	Limestone at 260 feet; 330 feet of 8-inch casing.
3	Manufacture of ice and boiler supply.	Vicksburg formation?	do	Water from cavities in limestone. Cost of well, $2,000; of pumping plant, $1,000. See log above.

[1] Georgia Geol. Survey Bull. 15, pp. 54, 55, 1908.

TABLE 85.—*Analyses of underground waters from Tift County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
	1911.				*Feet.*	
1	May 24	Town well	Tifton	Vicksburg formation?	300-550	Edgar Everhart.
2	.....	Well of H. H. Tift	....do	....do	330-368	H. C. White.[a]
3	.....	Well of Tifton Ice & Power Co.	....do	....do	340-512	Boiler Compound Co.[b]
4	Apr. 3	Murrow Mineral Spring.	Tifton, 4 miles west of.	Late Oligocene?	.....	Edgar Everhart.

No.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	28	0.2	.....	44	2.0	18		0.0	181	6.0	0.1	5.0	.....	192	Well 1, Table 84.
2	16	.1	5.3	73	.8	8.3	4.1	116	.....	12	.....	.7	7.0	250	Well 2, Table 84.
3	16	[c]3.8	.....	35	4.9	8		34	.....	49	.....	12	.....	176	Total depth of well 572½ feet. Well 3, Table 84.
4	22	.2	.....	38	2.0	6.0		.0	154	Tr.	Tr.	3.0	.....	168	

[a] Georgia Geol. Survey Bull. 15, pp. 54, 55, 1908. [b] Idem, p. 55. [c] $Fe_2O_3+Al_2O_3$.

TOOMBS COUNTY.

GENERAL FEATURES.

Toombs County is in the east-central part of the Coastal Plain of Georgia. Lyons, the county seat, is on the main line of the Seaboard Air Line Railway, 75 miles west of Savannah. The area of the county is 393 square miles and the population is 11,206 (census of 1910).

TOPOGRAPHY.

The county is for the most part slightly undulating to hilly, but some of the interstream areas are nearly level. Altamaha River, which forms the southern boundary, has cut 100 or 150 feet below the general upland level. Ohoopee River and Pendletons Creek, the next largest streams, are bordered on the east by low hills or ridges with conspicuous coverings of incoherent quartz sand, the origin of which has not yet been satisfactorily explained. Small branches and creeks are numerous and flow through swamps in broad shallow valleys.

The known altitudes at railroad stations are Lyons, 254 feet; Ohoopee, 187 feet; and Vidalia, 257 (?) feet. The elevation of the swamp along Altamaha River, estimated from bench marks established by United States Army Engineers, is 75 to 85 feet above sea level.

GEOLOGY.

The Alum Bluff formation, which consists of 100 feet or more of sands and bluish or drab sandy clays, in part fuller's earth, with interbedded layers of sandstone or aluminous grit, outcrops in the valley of Altamaha River and underlies the remainder of the county. The deposits contain water-bearing beds.

The Alum Bluff formation is overlain by 75 or 100 feet of irregularly bedded, locally indurated sands, sandy clays, and gravels, which probably are of Oligocene age, and which form the surface throughout nearly all the county. These materials are the source of the water obtained in shallow wells. Pleistocene terrace deposits occur in small areas along Altamaha River.

The Alum Bluff formation is underlain by a series of undifferentiated limestones, sands, clays, and marls, which in descending order are of Oligocene, Eocene, and Cretaceous age. At an unknown depth, perhaps 2,500 feet or more, the Cretaceous deposits rest upon a basement of ancient crystalline rocks.

The Oligocene, Eocene, and Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug wells 15 to 40 feet deep are the chief source of domestic water supply; most of them tap water-bearing beds in the surficial sands and gravels of Oligocene (?) age and yield soft potable waters suitable for household use, except where not properly protected from surface pollution. Deep wells have been drilled at Lyons and Vidalia.

Small seepage springs are scattered throughout the county but are comparatively unimportant as sources of water supply; most of them occur at the edges of the swamps bordering the streams and issue either from the base of sand hills or from sandy layers in the Oligocene (?) surficial deposits. An analysis of water from a spring owned by J. M. and C. S. Meadows, Normantown, is given in Table 87 (analysis 2).

The waters of streams are suitable for stock and boiler supply

Abundant supplies of artesian water can be obtained anywhere in the county at depths of 100 to 1,000 feet or more. The prospects for obtaining flows are good only on the low-terrace plains bordering Altamaha River and on the lowlands bordering Ohoopee River and Pendletons Creek.

LOCAL SUPPLIES.

Lyons (population 927, census of 1910).—Two public artesian wells have been drilled at Lyons. The first,[1] drilled in 1900, is 450 feet deep and the water rises to within 85 feet of the surface; the well is no longer in use. The second,[1] drilled in 1909, is 406 feet deep and is 8 inches in diameter at the top and 6 inches at the bottom. The principal supply is said to come from a sand at 400 feet, and the water rises to within 100 feet of the surface. This well furnishes the municipal water supply for both domestic and manufacturing purposes. (See analysis 1, Table 87.)

Vidalia (population 1,776, census of 1910).—The public water supply at Vidalia is obtained from a well 805 feet deep at the electric-light plant in the eastern part of the town. The water comes chiefly from limestones below 440 feet and rises to within 140 feet of the surface. Another water-bearing stratum was penetrated at about 400 feet but was cased off. The water from the limestones is suitable for drinking but is rather hard and is objectionable for boiler supply. The following log has been furnished by the driller:

Log of well at the electric-light plant, Vidalia.

	Thickness.	Depth.
	Feet.	*Feet.*
Clay	40	40
Marl (?)	30	70
Gray sandstone (water)	40	110
Laminated clay	27	137
Sandstone (water)	8	145
Sand	20	165
Drab laminated clay	30	195
Sand (water)	1	196
Dark-colored clay	20	216
Yellow ferruginous sandstone	8	224
Gray laminated clay	46	270
Sand (water bearing)	27	297
Clay	25	322
Sand	2	324
Laminated clay	11	335
Sand	1	336
Hard clay or shale	19	355
Sand with shells	20	375
Sand	20	395
Blue marl	40	435
Principally limestone, water bearing	365	800
Not reported	5	805

A sample from 800 feet is a glauconitic sandy marl.

A well at the ice factory, about one-fourth mile west of the Seaboard Air Line Railway station, is 507 feet deep and is cased to 377 feet, where a water-bearing stratum is said to have been entered. The water, which stands within 120 feet of the surface, is pumped at the rate of 93 gallons per minute. It is said to be much softer than the city water and is used for the manufacture of ice and for boiler

[1] McCallie, S. W., Georgia Geol. Survey Bull. 15, p. 171, 1908.

supplies. This well and the town well are about three-quarters of a mile apart and are at about the same elevation.

TABLE 86.—*Wells in Toombs County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation of mouth above sea level.
						Feet.
1	Lyons	Town		S. W. McCallie[a]	1900	254
2	do	do	E. L. Edenfield.	E. L. Edenfield	1909	254
3	Vidalia	do			1908	257?
4	Vidalia, ¼ mile west of Seaboard Air Line Ry.	Ice factory				257?

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute by pumping.	How obtained.	Quality.
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*		
1	450	2½	450?		85			Hard.
2	406	6	400–406		100	100	Air-lift pump	See analysis 1, Table 87.
3	805		440–500?	400	140			Hard.
4	507		337?		120	93		Fairly soft.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Eocene?		
2	Manufacturing, domestic.	do	Sand	6-inch casing to 200± feet. Diameter at top 8 inches and at bottom 6 inches. Cost of well, about $1,000.
3	Domestic	Eocene	Limestone	See log, p. 430.
4	Manufacture of ice and boiler supply.	Oligocene or Eocene.		

[a] Georgia Geol. Survey Bull. 15, p. 171, 1908.

TABLE 87.—*Analyses of well and spring waters from Toombs County.*

[Parts per million.]

	1	2
Silica (SiO_2)	9.0	2.4
Iron (Fe)	.6	.5
Aluminum (Al)		.1
Calcium (Ca)	9.0	1.8
Magnesium (Mg)	1.0	.7
Sodium (Na)	36	3.2
Potassium (K)		.3
Carbonate radicle (CO_3)	.0	
Bicarbonate radicle (HCO_3)	118	28
Sulphate radicle (SO_4)	6.0	1.4
Nitrate radicle (NO_3)	.1	
Chlorine (Cl)	11	5.2
Total dissolved solids	112	20

1. Well No. 2, Table 86. Sample collected Apr. 15, 1911. Edgar Everhart, analyst.
2. Spring owned by J. M. and C. S. Meadows, Normantown; water-bearing formation, Oligocene surficial material.

TURNER COUNTY.

GENERAL FEATURES.

Turner County is in the central part of the Coastal Plain of Georgia. Ashburn, the county seat, is on the Georgia Southern & Florida Railway, 85 miles south of Macon. The area of the county is 231 square miles, and the population is 10,075 (census of 1910).

TOPOGRAPHY.

Turner County is moderately hilly, but the hills are low and the valleys broad with gentle slopes. The general upland surface is 350 to 400 feet above sea level. Small ponds occur throughout the county, and in the west lime sinks indicate the presence of limestone at no great depth. The streams which drain the county originate in the Coastal Plain and are small and clear.

GEOLOGY.

Strata of Oligocene age underlie the entire county but have not been accurately discriminated. It is believed, however, that they represent in ascending order the Vicksburg, Chattahoochee, and Alum Bluff formations. The Vicksburg formation, which consists of 200 feet or more of limestones with interbedded layers of sand and clay, does not appear at the surface.

The Chattahoochee formation is lithologically similar to the Vicksburg formation, but probably does not exceed 100 feet in thickness. It comes to the surface in a small area in the extreme west. Both the Vicksburg and the Chattahoochee formations are believed to carry potable waters in great abundance.

The Alum Bluff formation, which consists of 100 feet or more of bluish sandy clays, sands, and sandstones, outcrops in a belt a few miles wide extending north and south in the extreme west. The formation contains water-bearing beds. The Alum Bluff formation is overlain by 100 feet or less of irregularly bedded coarse ferruginous sands and blusish sandy clays, which are probably also of Oligocene age. These beds form the surface materials throughout the remainder of the county and are the source of the waters obtained in shallow dug wells.

Deeply buried beneath the Vicksburg formation are undifferentiated deposits of Eocene age, probably representing in descending order the Jackson formation and the Claiborne group and perhaps, also, the Wilcox and Midway formations. They contain water-bearing beds. The Eocene deposits are underlain in turn by deposits of Cretaceous age, the aggregate thickness of which is probably between 1,500 and 2,500 *feet;* these deposits also contain water-bearing beds. The Cretaceous

deposits are believed to rest upon a deeply buried basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug wells 10 to 60 feet deep, yielding soft waters, are the chief source of domestic water supply. Deep wells have been drilled at Ashburn and Worth. Creek water is used locally for stock. A few of the small springs of the county are used for domestic water supplies.

Artesian water can be obtained anywhere in the county at depths ranging from 100 to 1,500 feet or more. On the lowlands bordering the larger creeks it is probably possible to obtain flows by drilling to depths exceeding 500 feet.

LOCAL SUPPLIES.

Ashburn (population 2,214, census of 1910).—The town of Ashburn obtains its municipal water supply from three deep wells drilled in 1895 by the J. S. Betts Lumber Co. but now owned by the municipality. The wells are about 500 feet deep and are 20 feet apart. The water rises to within 175 feet of the surface and the yield is 125 to 150 gallons per minute. The water, which is probably derived from the Vicksburg formation, is slightly hard, is low in total solids, and has proved satisfactory for domestic and manufacturing purposes. A sample of water from one of these wells, collected June 15, 1911, was analyzed by Edgar Everhart as follows:

Analysis of water from one of the public wells at Ashburn.

	Parts per million.
Silica (SiO_2)	26
Iron (Fe)	.4
Calcium (Ca)	24
Magnesium (Mg)	7.0
Sodium and potassium (Na+K)	8.0
Carbonate radicle (CO_3)	2.0
Bicarbonate radicle (HCO_3)	117
Sulphate radicle (SO_4)	8.0
Nitrate radicle (NO_3)	.2
Chlorine (Cl)	3.5
Total dissolved solids	100

Worth (population 169, census of 1910).—At Worth domestic water supplies are obtained in part from a well 375 feet deep, in which the water rises to within 10 feet of the surface.

McCallie [1] describes a well at this place, drilled by the Enterprise Lumber Co. in 1896, the depth of which is 300 feet. The water, which is probably derived from the Vicksburg formation, rises to

[1] Georgia Geol. Survey Bull. 15, p. 197, 1908.

within 60 feet of the surface. Limestone is said to have been encountered. The water was used for boiler supply.

TWIGGS COUNTY.

GENERAL FEATURES.

Twiggs County is in the north-central part of the Coastal Plain of Georgia. Its area is 314 square miles and its population (census of 1910) is 10,736. Agriculture and the mining of kaolin and high-grade clays are the chief industries.

TOPOGRAPHY.

The county is a dissected upland plain within the physiographic division known as the fall-line hills. Its central part forms the divide between the Ocmulgee and Oconee river systems. Numerous small creeks and branches flow southwestward into Ocmulgee River, and other small streams flow southeastward, eventually reaching Oconee River. Erosion by Ocmulgee River and the numerous small streams in the county has rendered much of the surface broken and hilly. In relatively narrow areas bordering Ocmulgee River Pleistocene terracing processes have produced two plains, one 10 to 20 feet and the other 60 to 75 feet above low-water level of the river.

GEOLOGY.

Eocene strata outcrop over the greater part of the county, perhaps reaching a maximum thickness of 200 feet at the extreme southern border. The Eocene beds rest unconformably upon Cretaceous strata which consist predominantly of irregularly bedded sands with subordinate clay lenses. These Cretaceous sands and clays outcrop in a narrow strip bordering Ocmulgee River along the western edge of the county and along the bottoms and lower slopes of the valleys of the small tributary streams entering Ocmulgee River from the east; they appear also in the valley of Big Sandy Creek in the north. Both the Lower and Upper Cretaceous are believed to be represented. Lower Cretaceous deposits lie immediately beneath the Eocene in approximately the northern third of the county. The Cusseta sand member of the Ripley formation (Upper Cretaceous) intervenes between the Lower Cretaceous and Eocene beds in a belt 4 or 5 miles wide in the west-central part of the county and extends eastward beneath the Eocene. In the southwestern part of the area the Providence sand member of the Ripley formation intervenes between the Cusseta sand and the Eocene and extends eastward beneath the Eocene. The Eocene deposits present in the county have been referred to the Claiborne group, the Jackson formation, and the

Vicksburg formation. The Claiborne group is composed of sands and clays, the Jackson formation consists chiefly of limestones, and the Vicksburg formation consists chiefly of the residual products of decomposed limestone. (See Pl. III, p. 52.)

Thin Pleistocene deposits of sandy loams, sands, and gravels cover narrow terrace plains along Ocmulgee River.

Water-bearing sands are numerous in the Cretaceous deposits and are present, though fewer in number, in the Claiborne group of the Eocene.

WATER RESOURCES.

Domestic water supplies throughout the county are obtained chiefly from dug or bored wells 30 to 100 feet deep and from numerous springs. Both wells and springs yield waters of excellent quality for domestic and industrial purposes. The numerous creeks and branches are sources of excellent water for stock and for steam making.

Lower and Upper Cretaceous deposits underlie the whole county but appear at the surface only in the valleys of Ocmulgee River and its tributaries along the western side of the county and in the valley of Big Sandy Creek in the north. The Cretaceous deposits are composed largely of beds of porous sand capable of carrying large quantities of water. In the northern part of the county these water-bearing beds lie at 100 to 300 feet and in the extreme south at probably 150 to 1,500 feet or more. The Eocene deposits, particularly the sandy strata of the Claiborne group, should yield small to moderate amounts of potable water at depths not exceeding 200 feet.

Conditions appear favorable for obtaining flowing wells in the valley of Ocmulgee River at elevations less than 50 feet above low-water level.

WARE COUNTY.

GENERAL FEATURES.

Ware County is in the southeastern part of the Coastal Plain of Georgia, its eastern boundary being about 50 miles from the Atlantic coast. Its area is 804 square miles and its population (census of 1910) is 22,957. The principal industries are lumbering and the manufacture of turpentine and resin, but increased attention is being given to agriculture, which will doubtless be the chief industry of the future.

TOPOGRAPHY.

The northern part is a gently rolling to nearly level upland plain having a very slight general southward slope and a maximum elevation of about 250 feet. The southern part is a swampy, poorly drained, pine and saw-palmetto flat lying 115 to 130 feet about sea

level. Okefenokee Swamp covers the extreme southern part of the county.

Satilla River, the largest stream, flows eastward across the northern part of the county and forms the northeastern boundary; it is a sluggish dark-water stream, flowing through a low, sand-covered, poorly drained terrace plain. Low-water level at the Atlantic Coast Line Railroad bridge, 3 miles northeast of Waycross, is about 70 feet lower than the surface at Waycross, where the altitude is 140 feet above sea level. The smaller streams spread out through swamps and carry a large amount of decayed vegetation.

GEOLOGY.

Throughout all but a few relatively small areas in the southern part of the county the surface terrane consists of 150 feet or less of irregularly bedded sands and clays which are probably of late Oligocene age. They weather to loose gray or yellowish quartz sands and are in part water bearing. At many places the materials immediately beneath the surface sands consists of mottled reddish, yellowish, and bluish argillaceous sands, in part cemented by iron oxide and locally known as hardpan. The remainder of the county is covered by sands and clays of Pleistocene age. The late Oligocene? beds are the source of the waters obtained in shallow wells.

A series of undifferentiated sands, clays, limestones, and marls of Tertiary age underlies the Pleistocene deposits and probably includes in descending order representatives of the Pliocene, Miocene, Oligocene, and Eocene. According to the log of a 700-foot well at Waycross (pp. 438–439) fossils corresponding to the Tampa formation (Oligocene) of Florida (=Chattahoochee formation of Georgia) were found at 415 feet. Limestones interbedded with layers of sand and shell marl, probably representing the lower portion of the Chattahoochee formation and the Vicksburg formation of the Oligocene, and perhaps also the Jackson formation of the Eocene, were encountered between 440 and 691 feet.

Nothing definite is known concerning the deposits beneath the limestones, but it is believed that they are underlain in descending order by sediments of Eocene and Cretaceous age, and that at some depth, perhaps 3,000 feet or more, the latter rest upon a basement of ancient crystalline rocks. Both the Eocene and Cretaceous deposits probably contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug and driven wells 10 to 40 feet deep are the chief source of domestic water supply. They yield an abundance of soft water which in wet seasons often stands within 3 or 4 feet of the surface.

The waters of the shallow wells are liable to contamination from surface sources owing to the porous character of the soils and subsoils. Deep wells have been drilled at Waycross and at Beach. (See Table 88.)

Springs are few in number, small, and of little value. The waters of streams and ponds are used to some extent for stock and for boiler supply.

Artesian water can be obtained anywhere at depths of 100 to 1,000 feet or more. Waters from deep sources, provided the wells are properly cased, are not subject to contamination from surface sources and are more suitable for all purposes, except boiler supply, than the waters of shallow wells and streams.

The prospects for obtaining flows are not good except on the lowlands bordering Satilla River, where flowing wells can probably be obtained at depths of 1,000 feet or more.

LOCAL SUPPLIES.

Waycross (population 14,485, census of 1910).—The city of Waycross owns a public water-supply system, which obtains water from two artesian wells, at the intersection of Plant Avenue and Mary Street. The surface at the mouth of the wells is about 2 feet lower than the Atlantic Coast Line Railroad station, which is 140 feet above sea level. According to H. M. Pafford, city engineer, the first well, drilled in 1893, is 700 feet deep, 12 inches in diameter at the top, and 8 inches in diameter at the bottom; and the second well, drilled in 1895, is 700 feet deep, 10 inches in diameter at the top, and 6 inches in diameter at the bottom. The principal water-bearing bed is between 670 and 700 feet, and the water rises to within 58 feet of the surface. The combined maximum yield of the wells is 1,800 gallons per minute. The city consumes 1,080,000 gallons of water per day, which is distributed from a standpipe having a capacity of 287,000 gallons.

The wells probably tap a water-bearing bed in Eocene deposits, possibly in the Jackson formation.

The water from the wells is clear and odorless, and although hard is of good quality for drinking, but, as it is rather high in calcium, magnesium, and sulphate it would probably produce considerable scale in boilers. (See analyses 2 and 3, Table 89.)

Although water for domestic and industrial purposes is furnished chiefly by the municipal water-supply plant, many shallow dug and driven wells owned by individuals are still in use, and some of the manufacturing concerns obtain their supplies from deep or shallow wells.

McCallie[1] gives the following log of one of the city wells, prepared from a set of well borings:

Log of city well at Waycross.

[Authority, H. Murphy, chairman of water works commission.]

	Feet.
Surface sand	2
Motley red, yellow, and white clays at	9
A rather coarse-grained, waterworn reddish sand at	20
A sample of sand differing mainly from the above in being of a reddish-brown color at	30
Coarse quartz sand cemented by iron oxide at	40
Dark gray plastic clay at	50
Very coarse white sand at	55
Very coarse white sand at	80
Dark gray clay at	100
Yellow sandy clay at	115
Fine gray sand containing glauconite at	130
Dark-gray clay at	140
Sandy clay with glauconite at	145
Fine glauconitic sandy clay at	160
Coarse white sand with glauconite at	185
Dark-gray greenish marl at	215
Medium fine-grained glauconitic sand at	217
Hard, flinty, sandy drab-colored claystone at	226
Drab-colored calcareous sandy clay with fragments of flint and limestone at	228
Hard vitreous glauconitic sand at	230
Gray glauconitic marl at	232
Fine dark-gray sand with fragments of shells at	234
Blue clay at	236
Gray sandy marl at	275
Coarse sand and phosphatic pebbles, sharks' teeth, dental plates of rays, and glauconite at	300
Fine sand with glauconite at	302
Hard compact sandstone at	310
Dark sandy clay with dental plates of rays and glauconite at	312
Gray marls, fragments of pectens, spines of sea urchins, etc., at	325
Very hard compact sandstone at	340
Fine gray glauconitic sand at	343
Shells at	380
Shell marl at	400
Highly fossiliferous limestone, Tampa horizon, at	415
Gray marl, pectens, and spines of sea urchins at	425
White chalky sandy limestone at	440
Fossiliferous limestone having a concretionary structure at	450
White chalky arenaceous limestone at	455
Gray sandy marl at	475
Fine yellow argillaceous sand at	480
Gray sandstone and claystone at	500
White chalky limestone at	510
Compact dark-gray limestone with fragments of corals and shells at	525

[1] Georgia Geol. Survey Bull. 15, pp. 181-185, 1908.

	Feet.
Shell marl at	527
White chalky limestone at	530
Dark gray marl with fragments of shells at	550
Hard, compact dove-colored glauconitic claystone at	555
White chalky limestone at	560
Gray porous limestone with casts of gastropods at	600
White chalky limestone at	610
White compact fossiliferous limestone at	650
"Peninsular" limestone, coral, Foraminifera, and bryozoans in abundance at	665
White chalky limestone at	670
White limestone made up largely of the tests of Foraminifera, some of which are an inch or more in diameter, at	675
White chalky limestone at	680
Dark-gray fossiliferous limestone at	685
Fossiliferous limestone, Basilosaurus horizon, at	691

Information has been obtained concerning two other deep wells at Waycross. One of them, owned by the Waycross Gas & Construction Co., is 647 feet deep and supplies water which rises to within 55 or 60 feet of the surface and is pumped at the rate of 500 gallons a minute. The other well, owned by the Hebard Cypress Co., at its lumber mill just outside the city limits, is 613 feet deep and contains water which stands within 57 feet of the surface.

Beach (population 358, census of 1910).—A deep well at Beach, owned by McMillan & Co., is 850 feet deep. The water, which rises to within 75 feet of the surface, is the principal domestic supply and is also used for making steam at a sawmill. It is clear, colorless, odorless, and wholesome.

TABLE 88.—*Wells in Ware County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Beach (500 feet east of the post office).	McMillan & Co.	.....	T. H. Calhoun	1904	.....
2	Waycross (Plant Ave. and Mary St.).	City	B. D. Finn	S. W. McCallie[a] and H. H. Pafford.	1893	138
3	....do	....do	....do	....do	1895	138
4	Waycross	Waycross Gas & Construction Co.	.....	H. H. Pafford	.....	.....
5	Waycross (near northwest city limits).	Hebard Cypress Co.	.....	....do	.....	.....

[a] Georgia Geol. Survey Bull. 15, pp. 181–183, 1908.

TABLE 88.—*Wells in Ware County*—Continued.

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	850	6	850	350	75	.....	50	Air-lift pump.....	See analysis 1, Table 89.
2	700	8	670–700	300 400	58	.....	900	.....do.....	See analyses 2 and 3, Table 89.
3	700	6	670–700	300 400	58	.....	900	.....do.....	Do.
4	647	6	.....	.....	58	.....	500	.....	
5	613	6	.....	.....	57	.....	.....	.....	

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic, boiler supply.	Claiborne group?..	Gravel and sand..	Cost of well, $1,700; pump, $500. Outside casing 6 inches, inside casing 4 inches, both inserted to 850 feet.
2	Domestic, industrial.	Jackson formation?	Porous limestone..	Diameter at top 12 inches, at bottom 8 inches.
3	.....do.....	.....do.....	.....do.....	Diameter at top 10 inches, at bottom 6 inches.
4	.....	.....do.....	Limestone.....	
5	.....	.....do.....	.....do.....	

TABLE 89.—*Analyses of underground waters from Ware County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
	1912.				*Feet.*	
1	Dec. 17	Well of McMillan & Co.	Beach.....	Claiborne group?..	850	Edgar Everhart.
	1911.					
2	Apr. 8	Town wells.....	Waycross.....	Jackson formation?	670–700	Do.
3	.....	.....do.....	.....do.....	.....do.....	670–700	H. C. White.[a]

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	44	3.0	33	16	25		0.0	193	27	0.0	12	.....	249	Well 1, Table 88.
2	45	.2	40	18	24		.0	175	49	.0	20	.....	290	Well 2, Table 88.
3	9.9	1.0	54	.6	2.8	0.5	78	.....	10	.....	3.6	16	177	

[a] Georgia Geol. Survey Bull. 15, p. 183, 1908.

WARREN COUNTY.

GENERAL FEATURES.

Warren County is in the northeastern part of Georgia on the border between the Piedmont Plateau and the Atlantic Coastal Plain. Its area is 404 square miles and its population (census of 1910) is 11,860. Agriculture is the chief industry.

TOPOGRAPHY.

Except for relatively small areas in the southeastern and southern parts of Warren County, which are in the Coastal Plain, the county lies in the Piedmont Plateau region. The Coastal Plain areas are on the northern border of the physiographic division called the fall-line hills. The southern part of the county is drained by the headwater streams of Ogeechee River, Rocky Comfort Creek, a tributary of Ogeechee River, and Brier Creek, a tributary of Savannah River. The dissection produced by these streams has rendered the surface hilly, the maximum topographic relief being probably between 250 and 350 feet.

GEOLOGY.

Crystalline rocks of the Piedmont Plateau outcrop at the surface over the greater part of the county. However, in relatively small areas in the south and east coarse arkosic sands and light massive clays of Lower Cretaceous age outcrop above crystalline basement rocks which extend southward beneath them. The maximum thickness of the Lower Cretaceous deposits probably does not exceed 100 feet. Small patches of strata referable to the Claiborne group of the Eocene cap the ridges in very small areas in the extreme southeast. (See Pl. III, p. 52.)

Although in texture and composition the Lower Cretaceous strata are good water bearers, they are too thin and too much dissected to be important as a source of water supply except for domestic purposes.

WATER RESOURCES.

Dug wells 25 to 100 feet deep and small springs furnish domestic supplies in the small Lower Cretaceous areas. Wells exceeding 100 feet in depth pass through the Lower Cretaceous deposits and enter the underlying crystalline rocks. The Lower Cretaceous sands are favorable in composition and texture to the storage of water, but on account of their high elevation and easy drainage they furnish only moderate supplies. However, the contained waters are soft and of good quality.

WASHINGTON COUNTY.

GENERAL FEATURES.

Washington County is in the northeastern part of the Coastal Plain of Georgia. Its area is 669 square miles and its population is 28,174 (census of 1910). Agriculture is the chief industry.

TOPOGRAPHY.

The northern part of the county is for the most part hilly and broken, with rather level interstream areas. Oconee River, which forms a part of the western boundary, has cut its valley about 250 feet lower than the plain on which Tennille and Sandersville are located. The southern part of the county is undulating and much less broken than the northern. The known elevations above sea level at railroad stations are Davisboro, 302 feet; Sunhill, 362 feet; Tennille, 477 feet; Oconee, 228 feet; and Oconee River bridge, 221 feet. The hills in the extreme northwest reach 500 feet above sea level. (See atlas sheet of Milledgeville quadrangle, U. S. Geological Survey.)

GEOLOGY.

Ancient crystalline rocks outcrop in the valley of Oconee River, Baldwin County, within a few miles of the northwestern boundary of Washington County, and in the valley of Ogeechee River, in the extreme northern part of Washington County. They slope southeastward beneath overlying sediments of the Coastal Plain and in the extreme southeastern part of the county probably lie 1,000 to 1,200 feet beneath the surface.

The crystalline rocks are overlain by 500 or 600 feet of irregularly bedded coarse sands with interbedded lenses of white clay of Lower Cretaceous age, which in turn are unconformably overlain throughout the greater part of the county by strata of Eocene age. Oconee River and Buffalo Creek in the west and Ogeechee River in the northeast have cut through the Eocene strata, bringing the Lower Cretaceous deposits to the surface along the sides and bottoms of their valleys.

The Eocene deposits, which probably reach a maximum thickness of 300 or 350 feet, have been referred to two divisions named in ascending order the Claiborne group and the Jackson formation. The Claiborne group, which is composed of 250 or 300 feet of red ferruginous sands and clays in the nature of fuller's earth and marls or impure limestones, outcrops throughout the greater part of the county north of the Central of Georgia Railway and in a few small areas south of that railway. The Jackson formation consists of limestones or the residual products of limestones, and appears at the surface in only a small area in the southwest.

Overlapping the Jackson formation and the Claiborne group in the southern part of the county and forming the surface materials are 75 feet or less of irregularly bedded sands and clays of undetermined but probably of late Oligocene age.

Pleistocene terrace deposits appear in narrow areas bordering Oconee River on the west.

The beds of porous sand which largely compose the Lower Cretaceous deposits carry large quantities of water, and sands carrying moderate amounts of water are present in the Claiborne group of the Eocene.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Shallow dug and driven wells 25 to 100 feet deep are the chief sources of domestic water supply in the county. In the north such wells, if located on the lowlands bordering the streams, tap water-bearing beds in the Lower Cretaceous deposits and yield soft waters. Those on the hills tap water-bearing beds in the Claiborne group. In the central part of the county shallow wells draw from the Claiborne group, and in the south from the late Oligocene? sands. Deep wells have been drilled at Sandersville, Tennille, Davisboro, and Oconee.

Small springs are numerous throughout the greater part of the county and furnish part of the domestic water supply. Large springs issue from limestones or marls of the Claiborne group near Sandersville, Tennille, Davisboro, and Sunhill.

The Lower Cretaceous deposits are present beneath practically the entire county, except in the valley of Oconee River and its tributaries on the west and in the valley of Ogeechee River in the north. They are concealed at the surface by overlapping Eocene beds which reach a thickness in the extreme southeast of perhaps 350 feet. As the Lower Cretaceous deposits are composed predominantly of sands, many beds of which are coarse and porous, they should contain numerous water-bearing beds, which should be reached in the northwest at 100 to 300 feet and in the southeast at a maximum of 1,000 to 1,100 feet. A flowing well has been obtained at Oconee, and flows can probably be had in the valleys of Oconee River and Buffalo Creek for several miles above Oconee and in the Oconee Valley below Oconee. A flowing well has also been obtained at Davisboro and flows can probably be obtained in the valley of Williamsons Swamp Creek from Davisboro downstream to the county line.

The Claiborne group contains beds of sand which are water bearing and which should be reached at depths not exceeding 300 or 400 feet.

LOCAL SUPPLIES.

Sandersville (population 2,641, census of 1910).—McCallie[1] has published information concerning deep wells at Sandersville, the county seat. The following log of the first city well (No. 3, Table 90) was prepared by McCallie from samples furnished by C. E. Worthen:

Log of first city well, Sandersville (No. 3, Table 90).

	Feet.
White and dark clays with pyrite at	35
White sandy limestone at	85
Gray limestone with fragments of shells at	103
Dark clay at	160
Yellow coarse sand at	215
White kaolin at	270
Fine white sand at	285
Dark pyritiferous sand at	335
White kaolin at	370
Rather coarse brownish sand at	387
White sand at	426
Fine white sand at	436

The materials at 35, 85, 103, and 160 feet probably belong to the Claiborne group of the Eocene. The strata below the dark clay at 160 feet are probably of Lower Cretaceous age. If this interpretation is correct the water-bearing beds at 325 and 425 feet are in the Lower Cretaceous deposits and those at 120 and 185 feet are in the Claiborne group.

Mayor A. W. Evans has furnished the following information concerning the municipal water plant at Sandersville:

The plant is under municipal ownership. The supply is derived from artesian wells (Nos. 3 and 4, Table 90). Air-lift pumps having a combined capacity of 200 gallons per minute raise the water to a reservoir with a capacity of 125,000 gallons, from which it is pumped to a tank with a capacity of 75,000 gallons. There are 6 miles of distributing mains. The standpipe pressure is 50 pounds and the direct pressure from the pumps 70 pounds. There are 200 taps for domestic purposes, 5 taps for manufacturing purposes, and 51 fire hydrants. Sixty-six thousand gallons are used daily. An analysis of the water is given in Table 91 (analysis 4).

McCallie says further: "The two private deep wells of Sandersville, one owned by Mr. Lewis Cohen, and the other by Dr. C. G. Rawlins, each has about the same depth as the deeper city well, and penetrates similar strata." The well owned by Mr. Cohen is 400 feet or more deep. The water is probably derived from a bed in the upper part of the Lower Cretaceous deposits. An analysis is given in Table 91 (analysis 5).

[1] Georgia Geol. Survey Bull. 15, pp. 185–187, 1908.

Tennille (population 1,622, census of 1910).—Information concerning the development of artesian supplies at Tennille is given by McCallie.[1]

In the report just cited[1] McCallie has published the following log of the first city well (No. 5, Table 90), which he obtained from the notes of the well contractor:

Log of first city well at Tennille (No. 5, Table 90).

	Thickness.	Depth.
	Feet.	*Feet.*
Sandy clay	38	38
White clay	14	52
Yellow sandy clay	28	80
White sand	11	91
Yellowish limestone in the form of bowlders	5	96
Gray sand	7	103
White sand	27	130
White sandstone containing shells	10	140
Bluish marl	45	185
Yellow clay	9	194
Brownish sand containing sharks' teeth and fragments of oyster shells	16	210
Blue marl	50	260
Quicksand	10	270
Blue marl	30	300
White clay	10	310
Blue clay	40	350
Blue and gray sands	10	360
Blue clay	44	404
Quicksand	32	436
White clay and sand	4	440
Coarse white sand	30	470
White "sticky" clay	30	500
Red clay	30	530
White clay	20	550
Clay and sand, except at 820 feet, where sandstone occurs	440	990

The upper 250 or 300 feet of strata is referred tentatively to the Claiborne group of the Eocene and the remainder to the Lower Cretaceous. An analysis of the water is given in Table 91 (analysis 6).

McCallie mentions a second city well, which is known to be about 300 feet deep and which probably penetrated water-bearing sands in the upper part of the Lower Cretaceous deposits.

Oconee.—A flowing artesian well has been drilled at Oconee. J. W. Barksdale, the postmaster, furnishes the following information:

The well was drilled by the town in 1908 on a slope about 75 yards northeast of the post office, 10 feet above the Central of Georgia Railway tracks and 231 feet above sea level. It is 140 feet deep and has 4-inch casing to 40 feet and 3-inch casing to 120 feet. The water comes from a bed of sand and gravel at the bottom of the well and will rise 10 feet above the surface; it now flows several gallons per minute 4 feet above the surface. Sand caving from the walls of the well below the end of the casing is slowly filling the boring and causing a gradual decrease in the flow. The water has a slight odor of hydrogen sulphide but is used for general domestic purposes. The cost of the well was $220.

[1] Georgia Geol. Survey Bull. 15, pp. 187–188, 1908.

The Oconee well penetrates Lower Cretaceous strata only, and the water comes from a bed of sand and gravel. An analysis is given in Table 91 (analysis 3).

Chalker.—At Chalker and vicinity there are many wells 50 feet or more, and some 100 feet in depth. All tap water-bearing beds in Lower Cretaceous deposits.

Davisboro (population 589, census of 1910).—McCallie[1] has described a flowing well (No. 1, Table 90) 325 feet deep, owned by the town of Davisboro, which yields 5 gallons per minute. The following is a log of the well:

Log of town well at Davisboro (No. 1, Table 90).

	Thickness.	Depth.
	Feet.	*Feet.*
Sand	20	20
Brownish clay with white pebbles	20	40
Coarse white sand	20	60
Dark greenish marl	20	80
Shell rock with sharks' teeth	8	88
Water-bearing sands with fragments of shells which continue to quicksand at the bottom of the well	237	325

The water-bearing bed is probably in the Claiborne group of the Eocene. An analysis is given in Table 91 (analysis 1).

Mineral Spring.—According to T. Julian Orr, of Davisboro, Mineral Spring, 4 miles west of Davisboro, owned by W. J. Henderson, possesses therapeutic properties. A mineral analysis of the water is given in Table 91 (analysis 2).

TABLE 90.—*Wells in Washington County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Davisboro	Town		S. W. McCallie [2]	1882	
2	Oconee	do	J. B. Carter	James W. Barksdale.	1908	231
3	Sandersville	do		S. W. McCallie [2]	1900	
4	do	do		do	1904	
5	Tennille	do		do	1892	477

[1] Georgia Geol. Survey Bull. 15, pp. 188, 189, 1908.
[2] Idem, pp. 185–189.

TABLE 90.—*Wells in Washington County*—Continued.

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	325	2	88–325	70–120	+ 3	5	.....	Flows.....	See analysis 1, Table 91.
2	140	3	120–140	.....	+ 10	Several.	.....	.....do.....	See analysis 3, Table 91.
3	436	4½	425	70, 120 185, 325	−134	.....	120	.....	Soft; see analysis 4, Table 91.
4	195	6	.....	.....	.....	.....	150	Pump.....	Hard.
5	990	4	.....	380–426	− 90	.....	.....	.....	See analysis 6, Table 91.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic.....	Claiborne group...	.....	See log, p. 446.
2	.....do.....	Lower Cretaceous.	Sand and gravel...	4-inch casing to 40 feet, 3-inch casing to 120 feet; caving of sand is decreasing flow.
3	.....	.....do.....	White sand.....	See log, p. 444.
4	Domestic.....	Claiborne group...	.....	12 inches in diameter at top, 4 inches at bottom.
5	.....	Lower Cretaceous.	Sand.....	Not used; another well owned by city is said to be 300± feet deep. See log, p. 445.

TABLE 91.—*Analyses of underground waters from Washington County.*

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	.....	Well owned by the town.	Davisboro.	Claiborne group.	88–325	Edgar Everhart.[a]
2	Apr., 1909	Mineral spring of W. J. Henderson.	Davisboro, 4 miles west of.	.....do.....	.....	Do.
3	Apr. 24, 1911	Town flowing well.	Oconee	Lower Cretaceous sand and gravel.	120–140	Do.
4	.....	First town well.	Sandersville	Lower Cretaceous.	70–325?	Do.[a]
5	Apr. 24, 1911	Well of L. D. Cohen.	.....do.....	.....do.....	400±	Do.
6	.....do.....	Town well.....	Tennille.....	.....do.....	380–426	Do.

[a] Georgia Geol. Survey Bull. 15, pp. 185–189, 1908.

TABLE 91.—*Analyses of underground waters from Washington County*—Continued.

[Parts per million.]

No.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Volatile and organic matter.	Total dissolved solids.	Remarks.
1	13	[a]4.0	59	1.8	14	3.7	105	.....	7.2	.....	5.6	.....	213	A trace of the phosphate radicle (PO_4). Well 1, Table 90.
2	17	a.6	56	.9	1.6	.6	.0	173	1.4	.....	3.0	.....	166	Free carbon dioxide (CO_2)=5.
3	16	1.0	29	3.0	14		.0	110	8.0	Tr.	3.5	.....	134	Well 2, Table 90.
4	27	a10	75	2.7	9.6	1.9	125	.....	4.2	.....	6.8	.....	264	Total depth of well 436 feet. A trace of the phosphate radicle (PO_4). Well 3, Table 90.
5	38	.2	60	6.0	8.0		.0	234	5.0	0.2	3.5	.....	234	
6	19	1.0	4.0	2.0	6.0		.0	12	Tr.	.5	12	.....	65	Well 5, Table 90.

[a] $Fe_2O_3+Al_2O_3$.

WAYNE COUNTY.

GENERAL FEATURES.

Wayne County is in the southeastern part of the Coastal Plain of Georgia. Jesup, the county seat, is at the intersection of the Atlantic Coast Line Railroad and the Southern Railway, 57 miles southwest of Savannah and 39 miles northwest of Brunswick. The area of the county is 764 square miles and the population is 13,069 (census of 1910).

TOPOGRAPHY.

The county presents two well-marked topographic divisions. The greater part of the area southeast of Jesup and the Waycross line of the Atlantic Coast Line Railroad is a poorly drained pine and saw-palmetto flat or plain lying 60 to 100 feet above sea level and containing many small swamps and cypress ponds. It forms part of the Okefenokee plain, and its soil, vegetation, and topographic aspect are characteristic of that physiographic division. The northwestern part of the county lies 100 to 175 feet above sea level, is slightly undulating, and is more completely drained. Its topographic aspect approaches that of the Altamaha upland or long-leaf pine region.

Altamaha River, which marks the northeastern boundary of the county, has its source in the Piedmont Plateau of Georgia and is a so-called muddy-water stream. On the Wayne County side it is bordered by high, steep bluffs. The smaller streams of the county are sluggish and are confined by low sandy banks or are spread out through swamps; their waters are black or coffee-colored from their high content of organic matter.

GEOLOGY.

From a few miles southeast of the Atlantic Coast Line Railroad to the northern part of the county undifferentiated Oligocene to Pleistocene deposits, consisting of 100 feet or less of irregularly bedded sands and clays, in part water bearing, form the surface materials and weather to loose gray sands. The remainder of the county is covered by sands and clays of Pleistocene age, probably not exceeding 50 feet in thickness. The undifferentiated and the known Pleistocene deposits are the source of the waters obtained in shallow wells. The undifferentiated sands, clays, limestones, and marls of Tertiary age, which underlie the surficial deposits, probably include, in descending order, representatives of the Pliocene, Miocene, Oligocene, and Eocene. (See logs of wells at Jesup, Mount Pleasant, and Doctortown pp. 450–453.) Strata belonging to the Miocene and to the Alum Bluff formation have been recognized in the bluffs of Altamaha River at and above Doctortown. It is believed that the Tertiary deposits are underlain by a considerable thickness of sediments of Cretaceous age, and that at some unknown depth, perhaps 3,000 feet or more, the Cretaceous deposits rest upon a basement of ancient crystalline rocks.

The Tertiary deposits and probably also the Cretaceous deposits contain important water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug and driven wells 10 to 30 feet deep tap water-bearing beds in the surficial deposits and are the chief sources of domestic water supply throughout the county. The waters obtained are soft, and where the wells are properly curbed to prevent contamination from surface sources are of satisfactory quality for domestic use; some of them, however, are rather strongly ferruginous. The driven well consists of a small iron pipe with a strainer point driven down to water-bearing sand and a small suction pump attached above the ground. This type of well is inexpensive and is practicable throughout the county, for water-bearing sands and gravels lie at small depths and no hard rocks are present. Such wells are preferable to open dug wells, because they afford less opportunity for pollution from surface sources.

Artesian wells have been drilled at Jesup, Doctortown, and Mount Pleasant.

Most of the few small seepage springs are in low swampy places, and many of them yield waters having an astringent taste or a strong

taste of iron. Streams and ponds furnish water for stock and for boiler supply.

Artesian water can be obtained anywhere at depths of 100 to 1,000 feet or more. The Tertiary limestones at 300 to 1,200 feet or more will yield large quantities of water.

It is probable that flowing wells can be obtained in the southeastern part of the county and in the valleys of the Altamaha, Satilla, and Little Satilla rivers wherever the elevation above sea level does not exceed 65 feet.

LOCAL SUPPLIES.

Jesup (population 1,415, census of 1910).—The town of Jesup has recently drilled a well 675 feet deep to obtain a municipal water supply. Water which rises to within 30 feet of the surface was obtained between 600 and 670 feet; the yield by pumping is 1,000 gallons per minute. (See well 3, Table 92, and analysis 1, Table 93.) The following log has been furnished by the Hughes Specialty Well Drilling Co., of Charleston, S. C.:

Log of town well at Jesup (No. 3, Table 92).

[Authority, C. C. Roberts, driller in charge.]

	Thickness.	Depth.
	Feet.	*Feet.*
Black soil	1	1
White sand	5	6
Red clay	12	18
Red sandy clay	37	55
Gray marl	20	75
Coarse light sand	50	125
Gray marl	10	135
White sand	15	150
Blue marl	15	165
Gray gravel	19	184
Hard gray sandstone	21	205
Blue marl	15	220
Hard gray layer of shells	35	255
Coarse gray sand	10	265
Hard gray layer of shells	25	290
Blue marl	5	295
Hard gray sandstone	25	320
Gray sandy marl	20	340
Hard sandstone	45	385
Coarse gray sand	10	395
Hard shell rock	70	465
White sand	10	475
Hard gray sandstone	60	535
Blue marl	15	550
Gray sandstone, water bearing in lower 30 feet	80	630
Gray sandy marl, water bearing	8	638
Hard gray sandstone, water bearing	37	675

The following log of a well, drilled in 1890 and owned by the town but not now in use, has been given by Spencer:[1]

Log of town well at Jesup (No. 2, Table 92).

	Thickness.	Depth.
	Feet.	*Feet.*
Sand	10	10
Quicksand	4	14
Yellow clay soil with layers of quicksand	12	26
Quicksand	26	52
Limestone	3	55
Quicksand	10	65
Limestone	13	78
Clay with sand	155	233
Soft spongy rock	4	237
Blue marl	253	490
Quicksand; water rose within 33 feet of the surface	(?)	(?)

The limestone at 55 feet probably corresponds to the Miocene marl exposed in the bluffs of Altamaha River near Doctortown.

Mount Pleasant.—Mount Pleasant is a village of 100 inhabitants in the southeastern part of the county at an elevation of 59 feet above sea level. A well owned by L. R. Akin is 729 5 feet deep and flows 10 feet above the surface. The water is used for domestic and boiler-supply purposes. (See well 4, Table 92, and analysis 2, Table 93.)

Another well (No. 5, Table 92) owned by the Southern States Pine Products Co., one-half mile southwest of Mount Pleasant, was drilled in 1906 by the Hughes Specialty Well Drilling Co. (J. R. Connelly, driller in charge). It is 560 feet deep and has 6-inch casing to 210 feet and 4½-inch casing to 345 feet. The main supply comes from 540 to 560 feet, but some water comes from 430 feet. The static head is 19½ feet above the surface and the well flows 150 gallons per minute. Mr. Connelly, who furnished the information just given, has also furnished a set of well samples (U. S. Geol. Survey well 1416) from which the following log has been prepared:

[1] Georgia Geol. Survey First Rept. Progress, p. 75, 1891.

Log of well of Southern States Pine Products Co., one-half mile southwest of Mount Pleasant (No. 5, Table 92).

	Thickness.	Depth.
	Feet.	*Feet.*
Fine gray sand	20	20
Fine gray sand containing fragments of shells	20	40
Coarse argillaceous sand with small fragments of fossils	13	53
Missing	2	55
Fine gray sand with small fragments of fossils	14	69
Soft gray sand, limestone, or marl, with numerous fragments of Ostrea, Pecten, etc	2	71
Fine gray, slightly argillaceous sand with small fragments of fossils	25	96
Gray, coarsely arenaceous clay	19	115
Gray, slightly argillaceous sand with small fragments of fossils	28	143
Missing	4	147
Fine gray, slightly micaceous and calcareous sand	13	160
Medium-grained clear quartz sand	5	165
Missing	3	168
Fine light-gray sand	26	194
Coarse clear sand, chiefly quartz; water bearing at 206 feet; water rises to within 10 feet of surface	16	210
Fine dark-gray argillaceous, slightly calcareous sand	75	285
Gray medium-grained sand with numerous small fragments of shells	8	293
Very fine micaceous, slightly argillaceous sand	40	333
Medium-grained calcareous clear quartz sand with scattered dark grains (phosphate?)	6	339
Missing	2	341
Gray sandy clay	11	352
Fine gray micaceous sand and chunks of sandy clay	28	380
Missing	20	400
Medium-grained, very calcareous clear quartz sand	18	418
Gray fine micaceous, argillaceous sand	4	422
Medium-grained calcareous clear quartz sand with dark grains (phosphate?); water bearing; water rises to 10 feet above the surface and flows at the rate of 30 gallons per minute	8	430
Fine gray calcareous sand	42	472
Medium-grained gray calcareous sand	4	476
(Samples labeled 440 to 470, 470 to 480, and 480 to 500 consist of coarse grains of quartz, dark pebbles of phosphate?, and fragments of limestone, and appear to be washings.)		
White sandy limestone; water bearing in lower 20 feet; water rises 19½ feet above the surface and flows 150 gallons per minute	84	560

Doctortown.—Doctortown is in the northeastern part of the county near Altamaha River. The following log of an oil-prospecting well, a mile to the southwest, has been published by McCallie:[1]

[1] Georgia Geol. Survey Bull. 15, pp. 190–192, 1908.

Log of oil-prospecting well near Doctortown (No. 1, Table 92).

[Authority, C. A. Gibson.]

	Thickness.	Depth.
	Feet.	*Feet.*
Sand	20	20
Sand and yellow clay with some shells	35	55
Sand and laminated clay	25	80
Conglomerate and marl; water rises to within 20 feet of the surface	15	95
Sand, gravel, and laminated clay	40	135
Greenish-gray marl and chalky limestone with some pebbles	50	185
Quicksand and marl	45	230
Layers of hard rock, marl, and conglomerate	25	255
Marl with sandstone layers and some limestone	40	295
Quicksand with layers of conglomerate	30	325
Soft limestone and sandstone with flint layers 2 feet thick	28	353
Quicksand	40	393
Marl and soft limestone	15	408
Quicksand containing a large supply of water	7	415
Quicksand	50	465
Soft limestone	2	467
Hard limestone with layers of sand	44	511
Water-bearing limestone (quicksand at 793 feet)	318	829
Gray limestone and brown sandstone	20	849
Sandstone	45	894
Limestone	35	929
Soft limestone	10	939
Salt water and sand	16.5	955.5
Hard limestone	10.5	966
Limestone in hard and soft layers	22	988
Limestone with some sand	17	1,005
Limestone	14	1,019
Limestone with two shell layers	17	1,036
Limestone with hard layers	15	1,051
Limestone, very hard	13	1,064
Limestone and sand	6	1,070
Limestone, mostly hard	134	1,204
Limestone	18	1,222
Hard limestone	33	1,255
Soft limestone	59	1,314
Hard limestone	18	1,332
Soft limestone	138	1,470
Gray and brown sands	170	1,640
Dark-brown sand	84	1,724
Sand mixed with pebbles	26	1,750
Light-colored sand	12	1,762
Glauconitic sand	139	1,901

This well was commenced in July, 1905, and completed the last of May, 1906, at a cost of between $15,000 and $20,000. It is cased with 10-inch pipe to 460 feet, 8¼-inch pipe to 540 feet, and 6-inch pipe to a point within a few feet of the bottom. The first hard ledge of rock reported in the well occurs at 480 feet. The sample of borings marked 550 to 725 feet contains numerous fragments of Eocene shells. The material consists largely of limestone, and it continues to 1,490 feet, below which point the following samples were collected:

Sample marked 1,470 feet consists of medium fine-grained sand with fragments of corals, shells, and particles of glauconite.

Sample marked 1,505 feet, glauconitic sand with sharks' teeth and fragments of shells.

Sample marked 1,750 feet, grayish marl made up largely of fragments of corals and shells.

Sample marked 1,838 feet, glauconite.

The well just described probably penetrates all the Tertiary deposits and enters the upper part of the Cretaceous, although no fossil evidence to this effect was obtained.

TABLE 92.—*Wells in Wayne County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Doctortown (near river).	Oil prospecting company.	C. A. Gilson	S. W. McCallie[a]	1906	74
2	Jesup	Town		J. W. Spencer[b]	1890	100
3	Jesup (500 yards northeast of post office).	do	Hughes Specialty Well Drilling Co., Charleston, S. C.; C. C. Roberts, driller in charge.	Hughes Specialty Well Drilling Co., Charleston, S. C., and James Steele, town clerk.	1912	100
4	Mount Pleasant	L. R. Akin	Fred Baumgartner, Brunswick.	Owner	1902	55±
5	do	Southern States Pine Products Co.	Hughes Specialty Well Drilling Co., Charleston, S. C.	J. R. Connelly, Varnville, S. C.	1906	59

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	1,901	6		80, 408, 511, 939					
2	490+				−33				
3	675	8	600–670		−30		1,000	Air-lift pump	See analysis 1, Table 93.
4	729.5	3			+10			Flows	See analysis 2, Table 93.
5	560	4½	540–560	206, 430	+19½	150		do	

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1		Cretaceous?		This is an oil-prospecting well. See log, p. 453.
2		Oligocene or Eocene.		This well is not now in use. See log, p. 451.
3	Municipal supply.	Eocene	Sandstone and sandy marl.	10-inch casing to 60 feet, 8-inch casing to 480 feet. Cost of well, $3,500; of pumps, $1,635. See log, p. 450.
4	Domestic and manufacturing.	do		Bored type.
5		Oligocene or Eocene.	Sandy limestone	210 feet of 6-inch casing and 345 feet of 4½-inch casing. See log, p. 452.

[a] Georgia Geol. Survey Bull. 15, pp. 190–192, 1908.
[b] Georgia Geol. Survey First Rept. Progress, p. 75, 1891.

TABLE 93.—*Analyses of well waters in Wayne County.*

[Parts per million.]

	1	2
Silica (SiO_2)	40	42
Iron (Fe)	6.0	4.0
Calcium (Ca)	19	31
Magnesium (Mg)	20	24
Sodium and potassium (Na+K)	26	25
Carbonate radicle (CO_3)	.0	.0
Bicarbonate radicle (HCO_3)	177	177
Sulphate radicle (SO_4)	35	70
Nitrate radicle (NO_3)	Trace.	Trace.
Chlorine (Cl)	7.0	18
Total dissolved solids	229	303

1. Well 3, Table 92. Sample collected Dec. 14, 1912; Edgar Everhart, analyst.
2. Well 4, Table 92. Sample collected Dec. 23, 1912; Edgar Everhart, analyst.

WEBSTER COUNTY.

GENERAL FEATURES.

Webster County is in the northwestern part of the Coastal Plain of Georgia. Its northern boundary is 25 to 30 miles south of the fall line. Its area is 302 square miles and its population is 6,151 (census of 1910). Agriculture is the chief industry.

TOPOGRAPHY.

The greater part of the county is a dissected upland plain and is hilly and broken except for some small, nearly level interstream areas. The northern upland lies 500 to 600 feet above sea level, but slopes slightly southward to 450 to 550 feet. Some of the streams have cut valleys 150 to 175 feet deep, and their small tributaries have cut precipitous V-shaped gullies or ravines.

GEOLOGY.

In the extreme northwest the Providence sand member of the Ripley formation (Upper Cretaceous), which appears at the surface, consists of coarse, irregularly bedded water-bearing sands with subordinate light-colored clay lenses and layers. The Providence sand is underlain by 1,200 to 1,500 feet of sands, clays, and marls, belonging in descending order to the Ripley and Eutaw formations of the Upper Cretaceous, but these do not appear at the surface within the county. They contain water-bearing beds and constitute a possible source of artesian water.

The Upper Cretaceous deposits are underlain by several hundred feet of water-bearing sands and clays of Lower Cretaceous age which, at an unknown depth, perhaps 2,000 or 2,500 feet, rest upon a basement of ancient crystalline rocks.

The Providence sand inclines slightly southeast and is overlain by several hundred feet of sands, clays, marls, and limestones of Eocene age which, although not accurately discriminated within the county, are believed to represent in ascending order the Midway and Wilcox formations and the Claiborne group. (See Pl. III, p. 52.) The Midway formation outcrops over nearly all the northwestern half of the county. The Wilcox formation outcrops in an irregular belt several miles wide, extending in a general northeast-southwest direction, through the southeastern part of the county. The Claiborne group appears in relatively small areas in the south and east. The Eocene formations contain important water-bearing beds.

On the narrow divide between Ichawaynochaway and Lochochee creeks, from a few miles northwest of Weston southeastward to the county line, is a thin overlapping sheet of red argillaceous sand containing fragments and masses of flint which belong to the Vicksburg formation of the Oligocene.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug or bored wells 30 to 90 feet deep are the chief sources of domestic water supply. Bored wells, when properly cased, yield safer drinking waters than dug wells. One deep well has been drilled at Preston.

Small springs are numerous and are used for domestic purposes on many of the farms. Most of the springs issue from noncalcareous sands in the Midway, Wilcox, and Claiborne formations, but a few are bold limestone springs. The best known is Cole Spring, on the south side of Kinchafoonee Creek, 2½ miles southeast of Preston.

The streams are clear and comparatively free from organic matter and are used locally for stock and for boiler supply.

It is possible to obtain artesian water in the county at depths of 100 to 1,500 feet or more. The prospects for obtaining flows are poor except perhaps in the lowlands bordering Kinchafoonee Creek in the extreme southeast.

LOCAL SUPPLIES.

Preston (population 259, census of 1910).—Preston has no public water-supply system, but owns a deep well located on the courthouse grounds, which furnishes a large part of the water for general domestic purposes. According to T. J. James, the driller, the well was completed in 1910, is 249 feet deep, and is 3 inches in diameter. The cost of the well and pumping machinery was $680. The principal water-bearing bed is sand at 499 feet and the water rises within 76 feet of the surface. The well is pumped by means of a gasoline engine and yields 500 gallons per hour. Mr. James has furnished the following log:

Log of town well at Preston.

	Thickness.	Depth.
	Feet.	*Feet.*
Sand	10	10
Clay and sand	90	100
Sand and marl	75	175
Alternating layers of hard rock 2 inches to 6 feet thick, and marl 1 foot to 15 feet thick; a water-bearing bed of small yield was struck at 240 feet, and sand, the principal water-bearing bed, at the bottom of the well	324	499

The well probably taps a water-bearing bed in the Ripley formation.

WHEELER COUNTY.

Since this report was transmitted for publication a part of Montgomery County has been segregated and organized as Wheeler County. This area is described in connection with Montgomery County (pp. 344–348).

WILCOX COUNTY.

GENERAL FEATURES.

Wilcox County is a little northwest of the center of the Coastal Plain of Georgia. Its area is 403 square miles and its population is 13,486 (census of 1910). Agriculture and the production of lumber and naval stores are the chief industries. Cottonseed-oil mills are located at Abbeville and Pitts; cotton gins and sawmills are distributed throughout the county.

TOPOGRAPHY.

The county is nearly level to slightly rolling, except in a narrow area in the east bordering Ocmulgee River, where the surface is somewhat hilly. From a few determinations of altitude it is estimated that the general upland surface is 300 to 450 feet above sea level. The highest part is the divide running northeast and southwest through the county between Ocmulgee and Alapaha rivers. According to a bench mark established by the United States Army Engineers at the Seaboard Air Line Railway bridge near Abbeville, the elevation of low-water level of Ocmulgee River is 169 feet above sea level. The river is bordered by two narrow terrace plains, one about 15 feet and the other 50 or 60 feet above low-water level of the river.

There are a number of lime sinks and lime-sink ponds in the eastern part of the county.

GEOLOGY.

The Vicksburg formation (of Oligocene age), which consists of 100 feet or less of limestones with interbedded layers of sand and clay, outcrops in the valley of Ocmulgee River in the extreme northeast.

The strata dip slightly southward and underlie the remainder of the county beneath younger formations. The Vicksburg formation is overlain by 100 feet or less of limestones belonging to the Chattahoochee formation of the Oligocene that outcrops on Ocmulgee River in the vicinity of Abbeville. Both the Vicksburg and Chattahoochee formations contain important water-bearing beds.

In the south the Chattahoochee formation is overlain by the Alum Bluff formation (of Oligocene age), which consists of 100 feet or less of bluish sands and clays, in part water bearing.

Overlapping the Alum Bluff, Chattahoochee, and Vicksburg formations and constituting the surface terrane throughout the greater part of the county is 75 feet or less of irregularly bedded sands and clays with subordinate lenses of claystone and conglomerate. The age of these deposits is not determined, but they are probably upper Oligocene.

The Vicksburg formation is underlain by several hundred feet of undifferentiated deposits of Eocene age, and the Eocene is underlain in turn by 1,000 feet or more of undifferentiated deposits of Cretaceous age, which rest upon a deeply buried basement of ancient crystalline rocks. The Eocene and Cretaceous strata do not appear at the surface within the county, but they contain important deeply buried water-bearing beds.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Water for domestic use is obtained chiefly from dug wells 10 to 40 feet deep. The shallow-well waters are generally soft and wholesome, and where the wells are properly curbed to prevent contamination from surface sources they are more suitable for boiler supply and laundry purposes than the artesian waters. Artesian wells have been drilled at Abbeville, Pineview, Pitts, and Rochelle. (See Table 94.)

A few bold limestone springs in the eastern part of the county afford clear water of good quality for drinking. Poor Robin Spring, near Abbeville, is described on page 460. The water of Abbeville Mineral Spring, near Abbeville, is bottled and sold for drinking purposes.

Artesian water can be obtained anywhere in the county at depths of 100 to 1,000 feet or more. Wells 600 feet deep in the valley of Ocmulgee River will probably flow where the elevation does not exceed 50 or 60 feet above low-water level.

LOCAL SUPPLIES.

Abbeville (population 1,201, census of 1910).—Abbeville owns a public water-supply system which obtains water from an artesian well. Although the water is regarded as hard it is wholesome for drinking.

About one-half of the domestic water supply of the town is furnished by the city plant and the remainder is obtained from shallow wells.

McCallie[1] gives the following information regarding wells at Abbeville:

There are two deep wells at Abbeville, one owned by the town and the other by the Abbeville Cotton Seed Oil Co. The former well, which was completed in 1898 at a cost of $1,600, is 585 feet deep. It varies from 2 to 8 inches in diameter and it furnishes 50 gallons of water per minute. The water rises to within 60 feet of the surface. Several water-bearing strata are reported between 100 feet and the bottom of the well. Cavernous limestone is said to be the main water carrier.

The Abbeville Cotton Seed Oil Mill well was put down in 1902 at a cost of $350. It is a 3-inch well, 175 feet deep, and it furnished daily 13,000 gallons of water, used chiefly for boiler purposes. The water rises to within 80 feet of the surface. Water-bearing strata are reported at 105 feet and 175 feet, respectively.

McCallie also gives the following log of the last-described well:

Log of well of the Abbeville Cotton Seed Oil Mill, Abbeville (No. 2, Table 94).

[Authorities, the owners.]

	Thickness.	Depth.
	Feet.	*Feet.*
Sand and clay	20	20
Sand	40	60
Hard flinty rock	115	175

Rochelle (population 860, census of 1910).—Rochelle owns an artesian well, but has not installed a system for distributing the water. However, the well is equipped with a pump, operated by a gasoline engine, which raises the water to a tank. The following information is given by McCallie:[1]

The Rochelle well is 3 inches in diameter and 286 feet deep. The only water-bearing stratum is near the bottom of the well. It furnishes a good supply of water, rising to within 150 feet of the surface. The water is used for general domestic purposes.

The following log of the town well at Rochelle is given by McCallie:

Log of town well, Rochelle (No. 6, Table 94).

[Authority, J. C. Conn, Atlanta.]

	Thickness.	Depth.
	Feet.	*Feet.*
Red clay	75	75
Black sand	75	150
Hard flinty rock	136	286

[1] Georgia Geol. Survey Bull. 15, p. 193, 1908.

Pineview (population 708, census of 1910).—A well owned by the town of Pineview is 210 feet deep and furnishes water for general domestic purposes to about 200 of the inhabitants. Rock is said to have been entered at a depth of 110 feet and the water rises to within 46 feet of the surface.

The following log of a well owned by J. S. Bruce at Pineview is given by McCallie:[1]

Log of well of J. S. Bruce, Pineview (No. 4, Table 94).

[Authority, the owner.]

	Thickness.	Depth.
	Feet.	*Feet.*
Reddish clays	20	20
Yellowish jointed clays	100	120
Soft limestone	155	275
Water-bearing cavity	18	293

Pitts (population 279, census of 1910).—At Pitts a well owned by the Pitts Oil Mill & Power Co. is 300 feet deep. The water rises to within 80 feet of the surface and is used for boiler supply.

Poor Robin Spring.—Poor Robin Spring, a mile north of Abbeville, yields 5,000 gallons per minute, according to the owner, W. L. Du Vall. The water rises under considerable pressure through openings in the bottom of a small limestone basin 15 or 20 feet deep and is remarkably clear. Fragments of flint found near the spring contain coral and other fossils which probably indicate that the limestone belongs to the Chattahoochee formation. Therapeutic properties have been ascribed to the water and the place is a local resort. The following analysis of a sample of the water collected June 1, 1911, was made by Edgar Everhart:

Analysis of water from Poor Robin Spring, Abbeville.

	Parts per million.
Silica (SiO_2)	14
Iron (Fe)	.4
Calcium (Ca)	54
Magnesium (Mg)	4.0
Sodium and potassium (Na+K)	3.0
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	185
Sulphate radicle (SO_4)	1.0
Nitrate radicle (NO_3)	.2
Chlorine (Cl)	3.5
Total dissolved solids	190

[1] Georgia Geol. Survey Bull. 15, p. 194, 1908.

TABLE 94.—*Wells in Wilcox County.*

No.	Location.	Owner.	Authority.	Date completed.	Approximate elevation of mouth above sea level.
					Feet.
1	Abbeville	City	S. W. McCallie [a]	1898	225
2	....do	Abbeville Cotton Seed Oil Mill	....do	1902	225
3	Pineview	Town	L. J. Wilson	1904	.....
4	....do	J. S. Bruce	Owner [a]	.....	.....
5	Pitts	Pitts Oil Mill & Power Co	J. N. McAllister	1897	.....
6	Rochelle	Town	J. C. Conn [a]	.....	.....

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	585	2	.....	.....	60	.....	50	.....	
2	175	3	175	105	80	.....	10	.....	
3	210	4	100	.....	46	.....	50	Deep-well pump...	
4	293	.....	275	.....	.....	.....	.....	.....	
5	300	4	.....	.....	80	.....	.....	Air-lift pump.....	Slightly sulphurous.
6	286	3	.....	.....	150	.....	.....	.....	

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Municipal supply.	Eocene.....	Rock.....	8 inches in diameter at top and 2 inches at bottom.
2	Boiler supply.....	Vicksburg formation.	.....	See log, p. 459.
3	Domestic.....	Vicksburg formation?	Soft rock.....	4-inch casing to 110 feet. Cost of well, $300; of pump, $50.
4	.....	Jackson formation?	.....	See log, p. 460.
5	Boiler supply.....	Vicksburg formation?	.....	
6	Domestic.....	.....do.....	.....	See log, p. 459.

[a] Georgia Geol. Survey Bull 15, pp. 193, 194, 1908.

WILKINSON COUNTY.

GENERAL FEATURES.

Wilkinson County is in the north-central part of the Coastal Plain of Georgia. Its area is 472 square miles and its population (census of 1910) is 10,078. Agriculture is the chief industry.

TOPOGRAPHY.

The county is included within the physiographic division called the fall-line hills. The surface, which was originally an upland plain, has been greatly dissected by Oconee River and its numerous tribu-

taries and is now very hilly. The maximum surface relief is probably between 300 and 400 feet.

Two Pleistocene terrace plains, not everywhere well defined, have been formed along the sides of Oconee River valley, one lying 10 to 20 feet and the other 30 to 40 feet above low-water level of the river.

GEOLOGY.

Crystalline basement rocks outcrop in the bed of Oconee River in the northern part of the county and extend southward beneath deposits of the Coastal Plain, their upper sloping surface probably lying at depths of 600 to 800 feet in the extreme south. The crystalline rocks are overlain by 500 or 600 feet of irregularly bedded coarse sands with commercially important interbedded lenses of white clay and kaolin, all of Lower Cretaceous age. The Lower Cretaceous sands and clays are unconformably overlain throughout the greater part of the county by Eocene strata. Porters and Commissioners creeks and Oconee River have cut through the Eocene deposits, bringing the Lower Cretaceous strata to the surface along the sides and bottoms of their valleys.

The Eocene deposits, which on the divides between the streams probably reach a maximum thickness of 150 or 200 feet, have been referred to two divisions—the Claiborne group and the Jackson formation. The Claiborne group is composed chiefly of sands and clays, and the Jackson formation consists of limestones or residual products of limestones. (See Pl. III.) Pleistocene terrace deposits have been laid down in small areas along the sides of the Oconee River valley.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

The domestic water supply in the county is obtained chiefly from dug wells 25 to 100 feet or more in depth and from small springs. The well waters are derived from beds of porous sand in the Lower Cretaceous deposits or in the Claiborne group of the Eocene. The waters of both wells and springs are commonly of good quality for domestic and industrial purposes. The numerous creeks and branches afford abundant water for stock and for steam production.

The whole county is underlain by Lower Cretaceous deposits containing numerous beds of porous sand carrying large supplies of artesian water. The Lower Cretaceous beds appear at the surface in the valleys of Big Sandy Creek and Oconee River and their tributaries; but in all the interstream areas they are concealed by overlapping Eocene strata which probably reach a maximum thickness of 150 or 200 feet in the southern part of the county. In the extreme north wells 100 feet deep would probably pass entirely through the Lower

Cretaceous deposits and enter the underlying basement rocks. The Lower Cretaceous deposits thicken southward beneath the Eocene deposits, and in the extreme south their water-bearing beds probably lie at depths of 200 to 800 feet. Small flows from Cretaceous water-bearing strata have been obtained on low ground at Irwinton and at Toomsboro, and it is probable that flowing wells can be drilled into the same source at low levels in the valleys of Big Sandy and Commissioners creeks and Oconee River in the southern half of the county.

Moderate amounts of potable water may be obtained from beds of porous sand in the Claiborne group of the Eocene, which can be reached at depths of 50 to 200 feet in the south and at less depths in the north.

LOCAL SUPPLIES.

Detailed information concerning all of the deep wells in the county, except that recently drilled at Toomsboro, has been published by McCallie.[1] The water-bearing strata in these wells are in the Lower Cretaceous deposits.

Irwinton (population 249, census of 1910).—McCallie described wells at Irwinton as follows:

> Two attempts have been made at Irwinton to obtain artesian water. The first of these wells, located on low ground, was put down to a depth of 300 feet, at which point a water-bearing stratum yielding a small flow was struck. This well continued to flow for a time, but it finally became filled with sand and was abandoned. The water is said to have had a rather offensive odor and an unpleasant taste, due, probably, to the presence of hydrogen sulphide and iron oxide.
>
> Another well, located on high ground, was extended to the depth of 600 feet, but the water did not rise higher than to within 50 feet of the surface.

Toomsboro (population 404, census of 1910).—Mayor S. J. Nixon has furnished the following information regarding a public well drilled at Toomsboro in 1912:

The well is 315 feet deep and was drilled by S. C. Attaway of Hawkinsville at a cost of $600. Its diameter is 2 inches, and 2-inch casing extends to a depth of 210 feet. Beds of water-bearing sand were encountered at depths of 185, 285, and 315 feet. The water flows 2 gallons per minute 2 feet above the surface, but will rise to 3 feet above it. It is used chiefly for drinking. As the casing extends to only 210 feet the water is doubtless a mixture from the beds at 285 and 315 feet. The age of the strata penetrated by the well is Lower Cretaceous. A sample collected December 16, 1912, was analyzed by Edgar Everhart as follows:

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[1] Georgia Geol. Survey Bull. 15, p. 194, 1908.

Analysis of water from a flowing town well at Toomsboro.

	Parts per million.
Silica (SiO_2)	16
Iron and aluminum (Fe+Al)	4.0
Calcium (Ca)	18
Magnesium (Mg)	2.4
Sodium and potassium (Na+K)	8.0
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	54
Sulphate radicle (SO_4)	13
Nitrate radicle (NO_3)	Trace.
Chlorine (Cl)	5.0
Total dissolved solids	94

McCallie describes other wells at this place as follows:

The Toomsboro well was put down in 1882 at a cost of $320. It is 1¼ inches in diameter and 320 feet deep; it furnishes a flow rising 3 feet above the surface. When the well was first completed it flowed 8 gallons per minute, but the flow gradually decreased until it finally ceased about four years after the well was completed. During last spring a second deep well was put down at Toomsboro, but no record of this well was secured.

Gordon.—One deep well has been reported from Gordon. McCallie says:

A 2-inch well, 365 feet deep, with water rising to within 19 feet of the surface, is reported at Gordon. About 20 feet of soft limestone, together with sands and clays, are said to have been penetrated in this well. The only water-bearing stratum reported is near the bottom of the well.

WORTH COUNTY.

GENERAL FEATURES.

Worth County is in the southwestern part of the Coastal Plain of Georgia. Its area is 651 square miles and its population is 19,147 (census of 1910). Agriculture is the chief industry, but the production of lumber and naval stores, though declining, is still carried on to an important extent. There are a few small manufacturing establishments at Sylvester and at Poulan.

TOPOGRAPHY.

The county is for the most part undulating or rolling, but some of the interstream areas are nearly level. The topography, soil, and native vegetation of the upland portion are characteristic of the physiographic division known as the Altamaha upland or long-leaf pine or wire-grass region. In the area drained by Abrams, Jones, and Swift creeks the surface is nearly level and is underlain by the limestones of the Chattahoochee and Vicksburg formations; here lime sinks are common. Flint River, which forms the northwestern boundary of the county, is bordered by two Pleistocene terrace plains,

one lying about 20 feet and the other about 60 feet above low-water level of the river.

With the exception of Flint River the streams are all small.

The known altitudes above sea level are Sumner, 350 feet; Poulan, 312 feet; Sylvester, 370 (?) feet; and Willingham, 299 feet. In the extreme northeastern part of the county, near the Tift and Turner county lines, the elevation of the higher land is believed to be approximately 400 feet.

GEOLOGY.

Strata of Oligocene age underlie the entire county. They have not been accurately differentiated, but it is believed that they represent in ascending order the Vicksburg, Chattahoochee, and Alum Bluff formations.

The Vicksburg formation, which consists of 200 feet or more of cavernous water-bearing limestones in interbedded soft and compact layers, outcrops in the banks and bluffs of Flint River and appears as residual sands and clays over a belt several miles wide in the extreme northwest.

The Chattahoochee formation is similar in its lithologic characters to the Vicksburg formation but probably does not exceed 100 feet in thickness. It comes to the surface in a narrow belt running northeast and southwest in the northwestern part of the county, where it is represented chiefly by residual sands and clays.

The Alum Bluff formation, which consists of 150 to 200 feet of bluish sandy clays, sands, and sandstones, outcrops in a narrow belt lying southeast of the outcrop of the Chattahoochee formation. It contains water-bearing beds.

The Alum Bluff formation is overlain by 100 feet or less of irregularly bedded coarse ferruginous sands and bluish sandy clays, perhaps of late Oligocene age. These beds form the surface materials throughout the remainder of the county and are the source of waters obtained in shallow wells.

Pleistocene terrace deposits have been laid down in narrow areas bordering Flint River.

Deeply buried beneath the Vicksburg formation are undifferentiated deposits of Eocene age, probably representing in descending order the Jackson formation and the Claiborne group and perhaps also the Wilcox and Midway formations. They contain water-bearing beds. The Eocene deposits are underlain in turn by deposits of Cretaceous age, the aggregate thickness of which is believed to be between 1,500 and 2,000 feet. These deposits also contain water-bearing beds. The Cretaceous deposits rest upon a deeply buried basement of ancient crystalline rocks.

WATER RESOURCES.

DISTRIBUTION AND CHARACTER.

Dug wells 20 to 50 feet deep are the chief source of water for domestic use. With the exception of those located in the northwestern part of the county they yield soft waters. Deep wells have been drilled at Sylvester, Oakfield, Doles, Poulan, and Warwick.

Artesian water can be obtained anywhere at depths of 100 to 1,500 feet or more. Waters from the Oligocene limestones are apt to be hard. Flowing wells may be had on the terrace plains bordering Flint River in the northwest. The source of the waters of such wells lies at depths of 500 to 1,000 feet or more and would be in the basal Eocene beds or the underlying Cretaceous deposits.

LOCAL SUPPLIES.

Sylvester (population 1,447, census of 1910).—Sylvester owns a water-supply system which obtains water from a well 720 feet deep, completed in 1908. The water rises to within 115 feet of the surface, and the maximum yield by pumping is estimated to be 750 gallons per minute, an amount more than sufficient to meet the present needs of the city. The elevation of the mouth of the well is about 3 feet lower than the level of the track at the station of the Atlantic Coast Line Railroad, where the altitude above sea level is 370 feet. It is estimated that the stratum penetrated at the bottom of this well (720 feet) corresponds approximately to the stratum penetrated at 550 feet in the wells at Albany. At Sylvester, therefore, it would be necessary to drill to a depth of 850 or 900 feet in order to reach the water-bearing stratum tapped at a depth of 680 feet in well No. 1 at Albany. The water from the 680-foot stratum at Albany is only slightly hard and is in other respects well suited for a municipal supply.

Several other wells owned by individuals at and near Sylvester range in depth from 100 to 250 feet and tap water-bearing cavities in limestones of the Chattahoochee formation. (See analyses 2 to 5, Table 96.)

Poulan (population 652, census of 1910).—At Poulan the chief sources of water for domestic use are shallow dug wells. There are three deep wells in the town.

A well owned by the Poulan Cotton Mills was originally 198 feet deep, but was deepened in 1908 to 409 feet, at which depth it probably reached the Vicksburg formation. (See analysis 1, Table 96.)

McCallie[1] gives the following additional information concerning wells at Poulan:

[1] Georgia Geol. Survey Bull. 15, pp. 196, 197, 1908.

The first attempt to secure water at Poulan by deep borings was made by Mr. J. C. McPhaul in 1890. Mr. McPhaul made two or three efforts to obtain a flowing well at Poulan, but each time he was unsuccessful. At the time of the writer's visit, in 1897, Mr. McPhaul furnished the following notes on his well, then in use: The well is from 6 to 8 inches in diameter and 315 feet deep. Water rises to within 75 feet of the surface. The main water-bearing stratum is reported as occurring at a point between 85 and 95 feet from the surface, but it is cased off. The static head of the water in the well is said to be lowered as much as 75 feet during a long-continued drought. The water is used chiefly for steam purposes, 75,000 gallons being used daily.

Mr. McPhaul has furnished the following record:

[*Log of well of J. C. McPhaul at Poulan (No. 5, Table 95).*]

	Feet.
Red clay to	15
Yellow clay to	20
White clay to	35
Hard rock at	75

The last extends to the bottom of the well.

Another deep well at Poulan, on which Mr. [W. W.] Burnham has furnished data, is the Jordan & Simerly well, located at a sawmill half a mile west of the post office. This well, completed in June, 1904, at a cost of $330, is 6 inches in diameter and 220 feet deep. Water-bearing strata are reported at 90 and 210 feet. Water rises to within 82 feet of the surface, or from 5 to 10 feet above the railroad track at the station. Sand and clay are reported in the well to 120 feet, limestone at 145 feet, and quicksand at 220 feet. The water is used only for boiler purposes.

Warwick (population 226, census of 1910).—A well owned by C. P. Romes[1] at Warwick is 497 feet deep and yields a large supply of sulphurous water. At a depth of 22 feet the drill entered a water-filled cavity 8 feet thick. The rocks penetrated in the well were chiefly limestone.

Doles.—A well owned by J. M. Chapman at Doles[2] is 257 feet deep and 3 inches in diameter and yields an abundance of water, which rises to within 12 feet of the surface. The following is a partial log:

Partial log of well owned by J. M. Chapman at Doles (No. 1, Table 95).

	Thickness.	Depth.
	Feet.	*Feet.*
Clay	15	15
Blue marl	81	96
Limestone	12	108
Coarse pebbles	15	123
Limestone with shells	20	143
Blue marl or clay	50	193
Limestone containing corals and shells	16	209
Flint	?	?
Not reported	?	257

Oakfield (population 276, census of 1910).—Several wells at Oakfield range in depth from 185 to 365 feet. Some of them flow, the maximum static head reported being 7 feet above the surface. A

[1] Georgia Geol. Survey Bull. 15, p. 197, 1908. [2] Idem, pp. 195, 196.

well owned by the town, completed in 1901, is 185 feet deep and contains water that rises to within 8 feet of the surface.

TABLE 95.—*Wells in Worth County.*

No.	Location.	Owner.	Driller.	Authority.	Date completed.	Approximate elevation above sea level.
						Feet.
1	Doles	J. M. Chapman				
2	Oakfield			W. J. Hall, mayor.		[a]
3	....do	Town	J. C. Cook	....do	1901	[a]
4	Poulan	Poulan Cotton Mills.	M. A. Jerrard	F. M. Kimble	1908	355
5	....do	J. C. McPhaul		S. W. McCallie [b]	1890	312
6	Poulan (½ mile west of).	Jordan & Simerly		....do	1904	
7	Sylvester	Town		W. W. Tison	1908	367
8	Warwick	C. P. Romes		S. W. McCallie [b]		

No.	Depth.	Diameter.	Depth to principal water-bearing bed.	Depth to other water-bearing beds.	Level of water above or below surface.	Yield per minute.		How obtained.	Quality.
						Flow.	Pump.		
	Feet.	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*		
1	257	3			− 12				
2	365				+ 7	60		Flows	
3	185	3	185	80, 160	− 8		12	Deep well pump	Soft.
4	409	4	140–360		− 85		100	Air-lift pump	See analysis 1, Table 96.
5	315	6	130–170	85–95	− 75		100+		
6	220	6	210–220	90	− 82				
7	720	6			−115		750	Air-lift pump	Hard; see analyses 2 and 3, Table 96.
8	497	2			− 5				Sulphurous.

No.	Use.	Principal water bed.		Remarks.
		Geologic horizon.	Character.	
1	Domestic	Vicksburg formation.		See log, p. 467.
2	....do	Eocene		
3	....do	Vicksburg formation?	Gravel	3-inch casing to 60 feet. Cost of well, $300; of pump, $20.
4	Domestic and manufacturing.	Tertiary		Cost of well, $750; of machinery, $275.
5	Boiler supply	Chattahoochee formation?	Hard rock	See log, p. 467.
6	....do	Alum Bluff formation?	Sand	Cost of well, $330.
7	Domestic and manufacturing.	Eocene or Cretaceous.	Limestone	
8		Eocene		8 inches in diameter at top and 2 inches at bottom.

[a] Elevation about 20 feet above low-water level of Flint River.
[b] Georgia Geol. Survey Bull. 15, pp. 196, 197, 1908.

TABLE 96.—*Analyses of underground waters from Worth County.*

[Parts per million.]

No.	Date of collection.	Source.	Location.	Principal water-bearing stratum.	Depth.	Analyst.
					Feet.	
1	May 24, 1911	Well of Poulan Cotton Mills.	Poulan.....	Tertiary.....	140–360	Edgar Everhart.
2	Apr. 3, 1911	Town well.....	Sylvester.....	Eocene or Cretaceous.	720	Do.
3	Oct. ,1908	.....do.....	.....do.....	.....do.....	720	Do.
4	Aug. ,1908	Old town well.....	.....do.....	Chattahoochee formation?	200±	Do.
5	.....do.....	Well of Joseph McGrill?	.....do.....	.....do.....	100	Do.

No.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Remarks.
1	22	0.4	.....	52	10	8.0		Tr.	224	6.0	0.4	5.0	213	Well 4, Table 95.
2	15	.4	.....	54	7.0	6.0		0.0	195	2.0	.2	7.0	.....	Well 7, Table 95.
3	15	.4	0.5	54	7.2	4.5	3.0	.....	195	2.3	.....	7.0	191	Free carbon dioxide (CO_2), 2. Phosphate radicle (PO_4), trace. Well 7, Table 95.
4	21	.1	.2	51	7.3	12	2.5	.....	198	.7	.....	7.0	204	
5	26	.4	.5	54	7.2	24	7.0	.0	209	2.0	.0	35	261	Free carbon dioxide (CO_2), 4. Phosphate radicle (PO_4), 1.6.

CHEMICAL CHARACTER OF WATERS OF THE COASTAL PLAIN OF GEORGIA.

By R. B. Dole.

STANDARDS FOR CLASSIFICATION.

MINERAL CONSTITUENTS OF WATER.

All natural waters contain dissolved or suspended materials derived from substances with which they have come into contact. They take up such materials in amounts determined principally by the chemical composition and physical structure of the substances, by the temperature, pressure, and duration of their contact, and by the condition of substances that they have previously incorporated. To designate such suspended and dissolved materials "impurities" is scarcely correct, because they have been introduced normally, in strict accordance with natural conditions and not necessarily by human agency. It has become customary, however, to call them impurities if their presence is detrimental to some proposed use of a water supply.

For purposes of examination the substances that may be present in natural waters are classified as suspended matter, such as particles of clay or leaves; dissolved matter, either of mineral or organic origin; microscopic animals or plants; and bacteria. The presence of very small animals and plants likely to affect the quality of waters is determined by microscopic examination, and the chance of contracting disease by drinking the water is ascertained by bacteriologic processes.

In the present study consideration is given chiefly to the suspended and dissolved mineral matter. The amount and nature of this are most commonly determined by estimating the total suspended matter, total dissolved matter, total hardness, total alkalinity, silica, iron, aluminum, calcium, magnesium, sodium, potassium, carbonates, bicarbonates, sulphates, nitrates, chlorides, free carbonic acid, and free hydrogen sulphide, these being the materials most commonly present and most likely to affect the value of the waters. Estimates of all of them are not necessary, however, in computing the economic value of a supply for a particular purpose, as will be shown in a discussion of the various practical uses of water.

USES OF WATER.

In judging the value of a water from its analysis it is necessary to consider the supply both in relation to its intended use and to other available supplies. Besides its general domestic use, water is essential in steam making, paper making, starch manufacture, and many other industrial processes. Many waters are valued for the supposed medicinal properties of their dissolved minerals. Much water is used for irrigation, both in the West and to some degree in the South, in the latter especially in rice growing. For each of these purposes the relative amounts of certain ingredients in a water determine its value and assist in its classification. For example, considerable iron in a water may be harmful in one industrial process and harmless in another. The value of a water for another purpose may be directly measurable by its suspended matter, its dissolved matter not being significant. Furthermore, many waters that are considered of great medicinal value are unfit for boiler use.

To catalogue waters as good or bad, hard or soft, pure or impure, is indefinite and may be misleading, unless the arithmetical values of such terms are rigidly defined. And even when the descriptive words in a classification are rigidly defined and carefully applied, it is highly advisable to know the intended use of a water and the composition of other available supplies before pronouncing final judgment as to its suitability.

WATER FOR BOILER USE.

FORMATION OF SCALE.

The most common trouble in boilers is the formation of scale or deposition of mineral matter within the boiler shell. When water is heated under pressure and concentrated by evaporation, as in a boiler, certain substances are thrown out of solution and solidify on the flues and crown sheets or within the tubes. These deposits increase fuel consumption because they are poor conductors of heat, and increase the cost of boiler repairs and attendance because they have to be removed. If the amount of scale is great or if it is allowed to accumulate, the boiler capacity is decreased and disastrous explosions are likely to take place.

The incrustation (scale) consists of the substances that are insoluble in the feed water or become so within the boiler under conditions of ordinary operation. It includes practically all the suspended matter or mud; the silica, probably precipitated as the oxide (SiO_2); the iron and aluminum, appearing in the scale as oxides or hydrated oxides; the calcium, precipitated principally as carbonate and sulphate; and the magnesium, found chiefly as oxide but also partly as carbonate. Scale is therefore a mixture which varies in amount,

density, hardness, and composition with the quality of the water supply, the steam pressure, the type of boiler, and other conditions of use. Calcium and magnesium are the principal basic substances in the scale, over 90 per cent of which usually is calcium, magnesium, carbonate, and sulphate. If much organic matter is present part of it is precipitated with the mineral scale, as the organic matter is decomposed by heat or by reaction with other substances. If magnesium and sulphate are comparatively low, or if suspended matter is comparatively high, the scale is soft and bulky and may be in the form of sludge that can be blown or washed from the boiler. On the other hand, a clear water relatively high in magnesium and sulphate may produce a hard compact scale that is nearly as dense as porcelain, clings to the tubes, and offers great resistance to the transmission of heat. Therefore the value of a water for boiler use depends not only on the quantity but also on the physical structure of the scale produced by it.

CORROSION.

Corrosion or "pitting" is caused chiefly by the solvent action of acids on the iron of the boiler. Free acids capable of dissolving iron occur in some natural waters, especially in the drainage from coal mines, which usually contains free sulphuric acid, and also in some factory wastes draining into streams. Many ground waters contain free hydrogen sulphide, a gas that readily attacks boilers, and some contain dissolved oxygen and free carbon dioxide, which are also corrosive. Organic matter is probably a source of acids, for waters high in organic matter and low in calcium and magnesium are corrosive, though the nature and the action of the organic bodies are not well understood. The chief corrosives are acids freed in the boiler by the deposition of hydrates of iron, aluminum, and magnesium, the last named being the most important as it is the most abundant. The acid radicles that were in equilibrium with these bases may pass into equilibrium with other bases, displacing equivalent quantities of carbonates and bicarbonates; they may decompose carbonates that have been precipitated as scale; they may combine with the iron of the boiler, thus causing corrosion; or they may do all three, their action depending on the chemical composition of the water. Even with the most complete analysis this action can be predicted only as a probability. If the acid thus freed exceeds the amount required to decompose the carbonates and bicarbonates, it attacks the iron of the boiler and produces pits or tuberculations of the interior surface, leaks, particularly around rivets, and general deterioration.

FOAMING.

Foaming is the formation of masses of bubbles on the surface of the water in the boiler and in the steam space above the water, and it is intimately connected with priming, which is the passage from the boiler of water mixed with steam. Foaming results when anything prevents the free escape of steam from the water. It is usually ascribed to an excess of dissolved matter that increases the surface tension of the liquid and thereby reduces the readiness with which the steam bubbles break. As sodium and potassium remain dissolved in the boiler water, while the greater portion of the other bases is precipitated, the foaming tendency is commonly measured by the degree of concentration of the alkaline salts in solution, because this figure, in connection with the type of boiler, determines to a great extent the length of time that a boiler may run without danger of foaming. It is a fact that the worst foaming waters in railroad practice are encountered in the arid and semiarid regions of the Southwest, where the quantity of dissolved alkali is greatest. However, it is well known that suspended matter can cause foaming, for certain surface waters that deposit a moderate amount of scale but do not foam when clear foam badly when they carry a great quantity of mud. Greth [1] states that foaming is due to condition of boiler, design of boiler, size and shape of water space, steam pipe, irregularity in blowing off, introduction of oil into the feed water from the exhaust steam, neglect to change water periodically, irregularity of load, or improper firing and feeding. He concludes that it is not merely the presence of sodium salts in solution that causes foaming, but the presence of other substances which together with the sodium salts and operating conditions brings about foaming. A strong solution of sodium carbonate might not induce excessive foaming in water otherwise pure, but its introduction into a boiler which under operating conditions invariably contains suspended matter or precipitated sludge might produce foaming by increasing the suspended matter either by precipitating calcium and magnesium or by loosening previously deposited scale. Under working conditions it is difficult to distinguish the actual cause of the trouble. Experience has shown that the type of boiler, steam pressure, and other operating conditions may greatly accelerate or retard foaming.

REMEDIES FOR BOILER TROUBLES.

The best way of remedying unsatisfactory boiler supplies is to treat them before they enter the boiler, but where this is impracticable trouble can be minimized in various ways. Low-pressure

[1] Greth, J. C. W., Water softening and purification for coal-mine operations: Paper read before the West Virginia Coal Mining Institute, Bluefield, W. Va., June 7, 1910.

large-flue boilers are used in many stationary plants with hard waters, and it is said that the scale formed in them is softer and more flocculent and can therefore be more readily removed than that formed in high-pressure boilers. Blowing off is about the only practical means of preventing foaming, because this trouble is due principally to concentration of substances in the residual water of the boilers. Accumulated sludge, or soft scale, is removed by blowing, particularly in locomotive practice. In condensing systems much of the trouble due to mineral matter in the feed water is obviated because the quantity of raw water supplied is proportionately small. Yet the problem is not completely solved in such systems, because the incrusting or corrosive action is transferred from the boiler to the condenser, which requires more or less cleaning and repairing in proportion to the undesirable qualities of the water supply.

BOILER COMPOUNDS.

Boiler compounds are widely used in regions where hard waters abound, but treatment within the boiler should be given only when it is impossible to purify the supply beforehand, or when the supply is relatively pure and requires only minor correction. If previous purification is not practicable, some feed waters can be improved by judicious addition of chemicals. Many substances, ranging from flour, oatmeal, and sliced potatoes to barium and chromium salts, have been recommended for such use, but only a few have proved to be really efficient. These substances have been classified[1] according to their action within the boiler. Those that attack chemically the scaling and corroding constituents precipitate incrusting matter and neutralize acids. Soda ash, the commercial form of sodium carbonate, containing about 95 per cent Na_2CO_3, is the most valuable substance of this character, because it is cheap and its use is attended with the least objectionable results. Tannin and tannin compounds are also used for the same purpose. The addition of limewater to the feed to prevent corrosion and to obviate foaming has been recommended,[2] and it is probable that it would improve waters high in organic matter and very low in incrustants. Such practice increases the incrustants in proportion to lime added but prevents corrosion. Soda ash neutralizes free acids, precipitates the incrusting ingredients as a softer, more flocculent material, which is more easily removed from the boiler and increases the foaming tendency of the water by increasing its content of dissolved matter. The proper amount to be used depends on the chemical composition of the water and the style of the boiler.

[1] Cary, A. A., The use of boiler compounds: Am. Machinist, vol. 22, pt. 2, p. 1153, 1899.

[2] Palmer, Chase, Quality of the underground waters in the Blue Grass region of Kentucky: U. S. Geol. Survey Water-Supply Paper 233, p. 187, 1909.

The second class of boiler compounds comprises those that act mechanically on the precipitated crystals of scale-making matter soon after they are formed, surrounding them and robbing them of their cement-like action. Glutinous, starchy, and oily substances belong to this class, but they are not now used to any considerable extent because they thicken and foul the water more than they prevent the formation of hard scale.

The third class comprises compounds that act mechanically, like those of the second class, and also partly dissolve deposited scale, thus loosening it and aiding in its ready removal. Of these, kerosene is very effective, but graphite is believed to be still better.

Many boiler compounds possessing or supposed to possess one or more of the functions just described are on the market and are widely sold. Some are effective and some are positively injurious. Most of them depend for their chief action on soda ash, petroleum, or a vegetable extract, but all are costly compared with lime and soda ash. Boiler compounds can not reduce the amount of scale and may increase it. Their only legitimate functions are to prevent corrosion and deposition of hard scale and to remove accumulations of scale that have become attached to the boiler. Every engineer should bear in mind that steam boilers are costly and that fuel and boiler repairs are expensive, and should hesitate to add substances to his feed water without competent advice as to their effect. It is far more economical to have the water supply analyzed and to treat it effectively by well-known chemicals in proper proportion, either within or without the boiler, than to experiment with compounds of unknown composition.

NUMERICAL STANDARDS.

The value of natural waters for boiler use depends primarily on their corroding and foaming tendencies and on the amount and character of scale likely to be deposited by them. This value, however, should always be considered in connection with local standards, for no matter how low a water may be in undesirable constituents it can not be classed as good if it is poorer in quality than the average water of the region in which it occurs. On the other hand, if the best available supply is poor the economy of purifying it, even at large expense, is obvious. Along the Atlantic coast, where waters containing less than 100 parts per million of incrusting ingredients are extremely common, a supply carrying 200 parts of such substances would not be considered fair for boiler use. Throughout most of the Mississippi Valley, however, such a supply would be considered good, because in that region natural waters not exceeding 100 parts in scale-forming constituents are rare. Because of this variance in local conditions, numerical standards should be interpreted relatively and

not literally. At the same time any classification by nominal ratings must be applied absolutely if the terms are to have comparative significance outside the region where the waters exist.

Stabler's excellent mathematical discussion of the quality of waters with reference to industrial uses [1] contains several formulas by which the effect of waters may be computed, and his formulas, quoted here in slightly altered form, have been used in classifying the waters discussed in the present report. The terms involving iron, aluminum, and free acids have been omitted because these substances are too scarce in most Georgia waters to call for consideration in such approximate ratings; and the terms involving sodium and potassium have been united for simplicity.

(1) $s = Sm + Cm + 2.95\ Ca + 1.66\ Mg$.
(2) $h = SiO_2 + 1.66\ Mg + 1.92\ Cl + 1.42\ SO_4 - 2.95\ Na$.
(3) $f = 2.7\ Na$.
(4) $c = 0.0821\ Mg - 0.0333\ CO_3 - 0.0164\ HCO_3$.

These equations express numerically some of the relations that have been discussed in the preceding sections on scale, corrosion, and foaming. Sm, Cm, SiO_2, Ca, Mg, Na, Cl, SO_4, CO_3, and HCO_3 represent the amounts in parts per million, respectively, of suspended matter, colloidal matter (oxides of silicon, iron, and aluminum), silica, calcium, magnesium, alkalies, chlorine, sulphate, carbonate, and bicarbonate. It is uncertain in some waters whether iron and aluminum are in solution or in colloidal state, but in applying these formulas to Georgia ground waters little error is introduced by assuming that they are colloidal.

The first formula gives the amount of scale-forming ingredients (s) that would probably be formed from the water under ordinary conditions of boiler operation. If it is desired to compute the scale-forming ingredients of waters whose analyses in this report give no values for silica, iron, or aluminum, Cm may be taken as 20 without introducing great error. In clear waters suspended matter (Sm) would of course be zero; and consequently for most Georgia ground waters the amount of scale may be estimated practically from the figures representing silica, calcium, and magnesium. Suspended matter can not, however, be disregarded in estimating the scale-forming ingredients of unsettled surface waters, for it frequently is greater than the dissolved matter.

The second formula gives the amount of the hard scale forming ingredients (h). The ratio $\frac{h}{s}$ expresses the relative hardness of the scale. If $\frac{h}{s}$ is greater than 0.5 the scale may properly be called hard; if it is less than 0.25 the scale may properly be called soft.

[1] Eng. News, vol. 60, p. 355, 1908; U. S. Geol. Survey Water-Supply Paper 274, p. 165, 1911.

The third formula gives the amount of the foaming ingredients (f) as estimated from the probable content of alkali salts.

The fourth formula has been used to calculate the corrosive tendency of the water (c). As can be readily seen from the coefficients, it expresses the relation between the reacting values of magnesium and the radicles involving carbonic acid (p. 472). If c is positive, the water is corrosive. If c+0.0499Ca (the reacting value of calcium) is negative, the mineral constituents will not cause corrosion; but whether organic matter or electrolysis will cause it is uncertain. If c+0.0499Ca is positive, corrosion is uncertain.

After these three attributes of boiler feed have been computed rating the water is largely a matter of judgment based on experience. The committee on water service of the American Railway Engineering and Maintenance of Way Association has offered two classifications by which waters in their raw state may be approximately rated; but, as the report states, "it is difficult to define by analysis sharply the line between good and bad water for steam-making purposes." Table 97 gives these classifications with the amounts transformed to parts per million.

TABLE 97.—*Ratings of waters for boiler use according to proportions of incrusting and corroding constituents and according to foaming constituents.*

Incrusting and corroding constituents (parts per million).		Classification.[a]	Foaming constituents (parts per million).		Classification.[b]
More than—	Not more than—		More than—	Not more than—	
.....	90	Good.	.....	150	Good.
90	200	Fair.	150	250	Fair.
200	430	Poor.	250	400	Bad.
430	680	Bad.	400	.....	Very bad.

[a] Proc. Am. Ry. Eng. and Maintenance of Way Assoc., vol. 5, p. 595, 1904.
[b] Idem, vol. 9, p. 134, 1908.

The classification by incrusting and corroding constituents has been applied to the computations of scale-forming ingredients (s) in the analytical tables accompanying this report. (See Tables 107–118, pp. 509–527.) The quantity of foaming ingredients (f) should always be considered in conjunction with the probable amount of scale or sludge that would be formed, the hardness of the scale, and the tendency toward corrosion. Those who are thoroughly familiar with local conditions in Georgia and with the chemistry of water will doubtless prefer to disregard the descriptive terms of the classification and draw their own conclusions regarding the quality of the waters from the figures representing scale, foaming constituents, and probability of corrosion. The classifications are given principally for the aid of those not thoroughly familiar with such matters and rather to indicate the limits of usefulness than to define rigidly the value of the waters.

Waters of poor quality can be improved by treatment in softening plants. How bad a water may be used without treatment depends on the cost of artificially softening the water and the relative saving effected by the use of the softened water. A report[1] of the committee on water service of the American Railway Engineering and Maintenance of Way Association sets forth the factors involved. The benefits include the saving in boiler cleaning, repairs, and fuel, the decrease in the time during which the boilers must be withdrawn from service for cleaning and repairs, the decrease in the depreciation of the boilers, and the value of the materials removed by softening. The cost of softening includes the cost of labor and power for the softening apparatus, the cost of softening chemicals, the interest on the cost of installation, depreciation in the value of the softening plant, and the waste in changing boiler feed due to increased foaming tendency.

In locomotive service it is, in general, economical to treat waters containing 250 to 850 parts per million of incrustants and to treat those containing less than 250 parts if the scale formed contains much sulphate.[2] As the incrusting solids may commonly be reduced to 80 or 90 parts per million, the economy of treating boiler waters deserves consideration in a region where many supplies contain 300 to 500 parts per million of incrusting matter.

The amount of mineral matter that makes a water unfit for boiler use depends on the combined effect in boilers of the softening reagents used with such waters and of the constituents not removed by softening. Sodium salts added to remove incrustants or to prevent corrosion increase the foaming tendency, and this increase may be great enough to render a water useless for steaming. It is not of much benefit to soften water containing more than 850 parts per million of nonincrusting material and much incrusting sulphate.[2] Trouble from priming in locomotive boilers begins at a concentration of about 1,700 parts per million of foaming constituents, and the limit of safety for stationary boilers is reached at a concentration of about 7,000 parts. Though waters containing as high as 1,700 parts per million of foaming constituents have been used, it is usually more economical to incur considerable expense in replacing such supplies by better ones.

WATER FOR MISCELLANEOUS INDUSTRIAL USES.

GENERAL REQUISITES.

Many articles are affected by the ingredients of the water used in their manufacture and can be improved by its purification. If by the same process the boiler efficiency of the factory can be increased the

[1] Proc. Am. Ry. Eng. and Maintenance of Way Assoc., vol. 8, p. 601, 1907.
[2] Idem, vol. 6, p. 610, 1905.

expense is often justified when it would not be warranted merely by the increased value of the product. This observation applies particularly to paper, pulp, and strawboard mills, laundries, and other establishments where large quantities of water are evaporated to furnish steam for drying, and to ice factories and similar plants where distilled water is required.

Besides its use for steam making water plays a specific part in many manufacturing processes. In paper mills, strawboard mills, bleacheries, dye works, canning factories, pickle factories, creameries, slaughterhouses, packing houses, nitroglycerin factories, distilleries, breweries, woolen mills, starch works, sugar works, canneries, glue factories, soap factories, and chemical works water becomes a part of the product or is essential to its manufacture. In most of these establishments the water is used principally as a cleansing agent or as a vehicle for other substances, and therefore a supply that is free from color, odor, suspended matter, microscopic organisms, and especially from bacteria of fecal origin, and fairly low in dissolved substances, especially iron, is generally satisfactory. But water that is also hygienically acceptable is necessary where it comes into contact with or forms part of food materials, as in the making of beverages, sugar, and dairy or meat products. As ideal waters for any use are rare, the manufacturer must ascertain what degree of freedom from substances is necessary to prevent injury to his machinery or to his output and whether the cost of obtaining such purity is counterbalanced by decreased cost of production and increased value of product. Competitive business methods and increased facilities of transportation have standardized the values of manufactured articles so thoroughly that makers are now obliged to scrutinize every item of production cost in order to obtain reasonable profits. Any appreciable saving effected by improvement of the water supply is one of the easiest sources of profit for the manufacturer.

EFFECTS OF DISSOLVED AND SUSPENDED MATERIALS.

The effects in some industries of the substances most commonly found in water are outlined in the following pages, the object being to offer approximate standards for classification.

FREE ACIDS.

Free mineral acids, such as the sulphuric acid in drainage from coal mines or the hydrochloric acid in the effluents of some industrial establishments, are especially injurious and nearly always have to be neutralized before the waters containing them can be used industrially. In paper mills, cotton mills, bleacheries, and dye works waters containing a measurable amount of free mineral acid decom-

pose chemicals, streak and rot fabrics, and corrode and rapidly destroy metal screens, strainers, and pipes.

SUSPENDED MATTER.

Suspended matter in surface waters may be of vegetable, mineral, or animal origin, as it consists of particles of sewage, bits of leaves, sticks, and sawdust, and sand and clay. The fine silt so common in rivers of the South is largely derived from clay. Few well waters contain suspended animal or vegetable matter, but many carry finely divided sand and clay, and many become turbid by precipitation of dissolved ingredients. Suspended matter is objectionable in all processes in which water is used for washing or comes into contact with food materials, because it is likely to stain or spot the product. Suspended matter due to precipitated iron is especially injurious even in small amount. Suspended vegetable or animal matter liable to decomposition or to partial solution is much more objectionable, even in small amounts (10 to 20 parts per million), than equal quantities of mineral matter. For these reasons water should be freed from suspended matter before being used for laundering, bleaching, wool scouring, paper making, dyeing, starch making, sugar making, brewing, distilling, and similar processes. In making the coarser grades of paper, such as strawboard, a small amount of suspended matter is not especially injurious, but for the finer white and colored varieties clear water is essential.

COLOR.

Color in water is due principally to solution of vegetable matter. Materials bleached, washed, or dyed light shades in colored water are likely to become tinged. Highly colored waters can be used in making wrapping or dark-tinted papers but not in making the white grades, and paper manufacturers are put to great expense for water purification on that account. The lower waters are in color, therefore, the more desirable they are for use in bleacheries, dye works, paper mills, and other factories where brown tints in the products are undesirable.

IRON.

Iron is the most undesirable dissolved constituent, and its presence in comparatively small quantities necessitates purification. Many ground waters in Georgia contain 1 to 20 parts per million of iron, which may be precipitated by exposure to the air and by release of hydrostatic pressure, causing the waters to become turbid; and many such waters develop rusty-looking gelatinous growths that may interfere in industrial operations. In all cleansing processes, especially if soap or alkali is used, precipitated iron is likely to cause rusty or dull spots. In contact with materials containing tannin

compounds iron forms greenish or black substances that discolor the product. Therefore many waters containing amounts even as small as 1 or 2 parts per million of iron have to be purified before they can be used industrially. In water for dye works iron is especially objectionable and commonly prevents the use of the water without purification.[1] Iron in the water supply of paper mills may be precipitated on the pulp, giving a brown color, or during sizing or tinting, giving spotty effects. Water containing much iron can not be used in bleaching fabrics, because salts that spot the goods are formed. The dark-colored compounds that iron forms with tannin discolor hides in tanning and barley in malting, and give beer a bad color, odor, and taste.[2]

CALCIUM AND MAGNESIUM.

Calcium and magnesium are similar in their industrial effects. In water their amounts bear a more or less definite relation to each other, most waters carrying 10 to 50 per cent as much magnesium as calcium. Both are precipitated on whatever is boiled in water containing them, forming a deposit that may interfere with later operations. They also decompose equivalent amounts of many chemicals employed in technical operations, causing waste and forming alkaline-earth compounds that interfere with the later treatment of fabrics. These troubles are the strongest incentives to preliminary softening. Some of the chemicals used to disintegrate the fibers in making pulp are consumed by the calcium and magnesium in the water supply, though the loss from this source is not nearly so great as that which occurs later when the resin soap used in sizing the paper is decomposed by the calcium and magnesium. The insoluble soaps thus created do not fix themselves on the fibers, but form clots and streaks. Similar decomposition of valuable cleansing materials and subsequent deposition of insoluble compounds take place in laundering, wool scouring, and similar processes. In the manufacture of soap calcium and magnesium form with the fatty acids curdy precipitates that are insoluble in water and therefore have no cleansing value. They interfere with many dyeing operations, neutralizing chemicals and changing the reactions of the baths, besides forming insoluble compounds with many dyes. Highly calcareous waters can not be used for boiling the grain in distilleries because they hinder proper action by causing the deposition of alkaline-earth salts on the particles of grain, nor for diluting spirits because they cause turbidity.[3] Very soft water, on the other hand, is said to be undesirable in paper mills for loading papers with any form of calcium

[1] Sadtler, S. P., A handbook of industrial organic chemistry, Philadelphia, p. 483, 1900.
[2] De la Coux, M. A. J., L'eau dans l'industrie, Paris, pp. 187, 232, 1900.
[3] Idem, p. 251.

sulphate, because such waters dissolve part of the loading materials.[1] Probably waters high in chlorides would also be bad for this purpose, because chlorides increase the solubility of calcium sulphate.

CARBONATES.

The effects of carbonates and bicarbonates in waters used in industrial processes are not differentiated in this paragraph. It is not unusual to estimate the combined carbonic acid and to state it as the carbonate without distinguishing between carbonates and bicarbonates, though in most natural waters of Georgia the carbonate radicle is absent and the combined carbonic acid is in the form of bicarbonates. If hard waters proportionately high in carbonates and low in sulphates are boiled, the bicarbonate radicle is decomposed, free carbonic acid is given off, and the greater part of the calcium and magnesium is precipitated. Consequently waters of that character are generally more desirable for industrial operations than waters high in sulphates and low in carbonates, whose hardening constituents are not greatly reduced by boiling. In beer making waters high in carbonates are said to produce dark-colored beers with a pronounced malt flavor because the carbonates increase the solubility of the nitrogenous bodies, whereas waters high in sulphates yield pale beers with a definite hop flavor because the sulphates reduce the solubility of the malt and the coloring matters.[2]

SULPHATES.

The influence of sulphates in beer making has been noted. Hard waters with sulphates predominating are desirable in tanning heavy hides because they swell the skins, exposing more surface for the action of the tan liquors.[3] Sulphates, however, interfere with crystallization in sugar making by increasing the amount of sugar retained in the mother liquor.

CHLORIDES.

High chlorides are usually accompanied by high alkalies in Georgia waters. Appreciable amounts of chlorides are injurious in many industrial processes. Beverages and food products, of course, can not be treated with waters very high in chlorides without becoming salty. In tanning, chlorides cause the hides to become thin and flabby.[3] Animal charcoal used in clarifying sugar is robbed of its bleaching power by absorption of salt, and the quality of sugars is affected by chloride-bearing waters because saline salts are incorpo-

[1] Cross, C. F., and Bevan, E. J., A textbook of paper making, New York, p. 294, 1900.

[2] Brewing water, its defects and remedies, American Burtonizing Co., New York, p. 19, 1909. Also De la Coux, op. cit., p. 169.

[3] Parker, H. N., and others, The Potomac River basin: U. S. Geol. Survey Water-Supply Paper 192, p. 194, 1907.

rated in the crystals.[1] In the preparation of alcoholic beverages chlorides in large amount prevent the growth of the yeast and interfere with the germination of the grain. The only commercially developed way of removing chlorides from water is distillation. As the cost of this process has been greatly reduced by the use of multiple-effect evaporators, it is worth considering where chloride-bearing waters must be used.

ORGANIC MATTER.

Organic matter of fecal origin is of course dangerous in any water that comes into contact with food products, and water so polluted should be purified before being used. Care in this respect is particularly necessary in creameries, slaughterhouses, canneries, pickle factories, distilleries, breweries, and sugar factories. Organic matter not necessarily capable of producing disease is further undesirable in industrial supplies because it induces decomposition in other organic materials like cloth, yarn, sugar, starch, meat, or paper, rotting and discoloring them, and because it causes slime spots on fabrics by supporting algæ growths.

HYDROGEN SULPHIDE.

Hydrogen sulphide (H_2S), a gas with an odor like that of rotten eggs, occurs dissolved in some underground waters and gives them what is known as a "sulphurous" taste and odor. It is corrosive even in small quantities, and it also injures materials by discoloring and rotting them.

MISCELLANEOUS SUBSTANCES.

Silica and aluminum are usually not present in sufficient quantity appreciably to affect any industrial processes except those in which water is evaporated. Large quantities of sodium and potassium, by adding to the amount of dissolved matter, are objectionable in some manufacturing operations. Phosphates, nitrates, and some other substances not noted in this outline interfere with industrial chemical reactions, but they are present in few natural waters in sufficient quantity to have noticeable effect.

WATER FOR DOMESTIC USE.

PHYSICAL QUALITIES.

Entirely acceptable domestic supplies are free from suspended matter, color, odor, and taste and are fairly cool when they reach the consumer. The more nearly waters fulfill these conditions the more satisfactory they are for general use. Suspended mineral matter clogs pipes, valves, and faucets, and growths of microscopic plants

[1] De la Coux, M. A. J., op. cit., p. 152.

suspended in water frequently cause odors and stains. The outlets of some artesian wells are surrounded by growths of microscopic organisms, which form tufts or layers in pipes and well casings and sometimes clog them. Detached particles escape through faucets, giving the water an unsightly appearance and staining clothes washed in it. So far as known such growths in tanks and mains do not cause disease, but they often impart unpleasant odors that make the water objectionable. True color is usually due to dissolved vegetable matter, and causes serious objection only when it exceeds 20 to 30 parts per million.

In general, Georgia well waters are satisfactory in respect to suspended mineral matter and color. Finely divided material from quicksands enters some driven wells, but such trouble is not so serious as it is in other parts of the country. A few waters, especially those containing iron, develop a turbidity of 10 to 30 parts per million on exposure to the air by precipitating dissolved matter, and such condition gives rise to apparent though not to real color. The odor most commonly noticed in the ground waters of Georgia is that of hydrogen sulphide.

BACTERIOLOGIC QUALITIES.

Before a water is used for domestic purposes there should be reasonable certainty that it is free from disease-bearing organisms and that it can be guarded against all chances of infection. The disease germs most commonly carried by water are those of typhoid fever. The bacilli enter the supply from some spot infected by the discharges of a person sick with this disease, and though comparatively short lived in water they persist and retain their power of infection in fecal deposits for remarkable lengths of time. Consequently, water from lakes and streams draining from pollution centers or from irrigated fields should not be used for drinking without purification. Wells should be so located as to be guarded against the entrance of filth of any kind, either over the top or by infiltration. Pumps and piping in the system should also be protected. Water from a carefully cased well more than 20 or 30 feet deep is acceptable if the well is located at a reasonable distance from privies, cesspools, and other sources of pollution. Many open dug wells and pits constructed as reservoirs around the tops of casings are exposed to fecal contamination from above or through cracks in poorly built side walls. Care should be taken that the casings of deep wells do not become leaky near the surface of the ground so as to allow pollution to enter. As a matter of ordinary precaution the ground should be kept clean and water should not be allowed to become foul or stagnant near any well, no matter how deep. If shallow dug wells are necessary, they should be constructed with water-tight walls extending as far as practicable

into the well and also a short distance above ground. The floor or curbing should be water-tight, and pumps should be used in preference to buckets for raising the water. Every possible precaution should be taken to prevent feet scrapings and similar dirt from getting into the well. Underground water is not only less likely to become contaminated when protected from surface washings, air, and light, but it keeps better and is less likely to develop microscopic plants that give it an unpleasant taste.

CHEMICAL QUALITIES.

The amounts of dissolved substances permissible in a domestic supply depend much on their nature. No more than traces of barium, copper, zinc, or lead should be present, because these substances are poisonous; however, their occurrence in measurable amounts in ordinary waters is so rare that tests for them are not usually made. Any constituent present in sufficient amount to be clearly perceptible to the taste is objectionable. Water containing two parts per million of iron is unpalatable to many people and may cause trouble by discoloring washbowls and tubs and by producing rusty stains on clothes. Tea and coffee can not be made satisfactorily with water containing much iron because a black inky compound is formed. Four or five parts of hydrogen sulphide make a water unpleasant to the taste, and this gas is objectionable also because it corrodes well strainers and other metal fittings. The amounts of silica and aluminum ordinarily present in well waters have no special significance in relation to domestic supply.

Approximately 250 parts of chlorine make a water "salty," and less than that amount causes corrosion. In regions where the chlorine content runs as low as 5 or 10 parts in normal waters unaffected by animal pollution the amount of chlorine is frequently taken as a measure of contamination. But the establishment of isochlors, or lines of equal chlorine, in Georgia would be of little sanitary value, because many of the waters dissolve so much chloride from the sedimentary deposits of the Coastal Plain that the small changes caused by animal pollution are not discernible.

Calcium and magnesium are the chief causes of what is known as the hardness of water. This undesirable quality is indicated by increased soap consumption and by deposition on kettles of scale composed almost entirely of calcium, magnesium, carbonates, and sulphates. Calcium and magnesium, forming with soap insoluble curdy compounds that have no cleansing value, prevent the formation of a lather until these two basic radicles have been precipitated. Hardness is measured by the soap-consuming capacity of a water expressed as an equivalent of calcium carbonate ($CaCO_3$), and it can be determined by actual testing with a standard solution of soap or

can be computed from the amounts of calcium (Ca) and magnesium (Mg) by means of the following formula:

$$\text{Total hardness as } CaCO_3 = 2.5\ Ca + 4.1\ Mg.$$

Soda ash (sodium carbonate) is used in many regions to "break" or soften hard water in order to save soap.

MINERAL MATTER AND POTABILITY.

The lower waters are in mineral content the more acceptable they are as sources of domestic supply. The amount of dissolved substances that can be tolerated in drinking water is, however, much greater than that allowable in city supplies, for which hardness, corrosion, pipe clogging, and general utility have to be considered. Though there are certain limits above which the common ingredients are intolerable, these limits are not only difficult to ascertain but are also liable to shift. A normal water is not a pure solution of one salt whose physiologic effect can be measured, but an indeterminate mixture of solutions of several salts whose effects are not easily differentiated. Further, though all animals select for drinking waters that are lowest in solids and avoid those that are highest, the same animals, when transported to districts of poor water, accustom themselves to supplies of far greater mineral content than those they would not touch before. Consequently any general limits that may be assigned to the various mineral ingredients must be regarded as extremely flexible.

The degree of mineralization that can be tolerated in alkaline sulphate waters is greater than that allowable in alkaline chloride waters, and is considerably greater than that allowable in alkaline carbonate waters. Strong calcium sulphate waters can not be used for boiling vegetables and are likely to cause diarrhea, as the presence of calcium necessarily implies the presence of magnesium, which in large quantity is laxative. Calcium carbonate waters are extremely common, but it is unusual for them to be so highly mineralized as to cause noticeable physiologic effect.

The usual immediate consequence of drinking waters too high in mineral content is diarrhea. Many persons at first afflicted with this trouble become accustomed to the new supply and acquire what may be termed immunity. Whether other disorders result from the continued drinking of such waters is not known; and it is equally uncertain whether cattle and horses that so commonly are reported to have been killed by drinking mineral water were killed by the purging of the mineral matter or by the excessive consumption of the water itself. Waters exceeding 300 parts per million of carbonate, 1,500 parts of chloride, or 2,000 parts of sulphate are apparently intolerable to

most people. These limits are fortunately far beyond the points where the substances in solution become clearly perceptible to the ordinary taste. In conclusion it can not be too emphatically stated that information on this subject is fragmentary and uncertain and that any limits of mineral tolerance are modified by individual idiosyncrasy.[1]

WATER FOR MEDICINAL USE.

The term "mineral" may reasonably be applied to all natural waters, as all contain dissolved mineral matter, but is commonly restricted to natural spring waters irrespective of whether they are highly or slightly mineralized or whether they are deemed good table waters or reputed to have specific therapeutic properties. The term "medicinal" usually is and should be used to distinguish highly mineralized waters that may cause specific physiologic reaction from those that are low in mineral constituents and are especially acceptable as table waters by reason of their attractive physical characteristics and freedom from contamination. Though the literature on mineral waters is voluminous and though many schemes for the classification of waters reputed to have curative properties have been devised, yet comparatively little has been published on the relations between the concentration of the various dissolved substances and their effects within the body. Further, the distinction between waters having therapeutic action by virtue of their content of certain mineral substances and those having possible therapeutic action only as water itself has not been generally recognized.

It seems entirely reasonable to conclude that the specific reactions caused by the radicles in natural waters are similar to those caused by the same radicles in simpler artificial solutions, and that the force or strength of such reactions depends on the concentration of the radicles. In other words, the probability of medicinal action due to the dissolved substances in natural waters can be judged by comparing the concentration of such substances with equivalent concentrations of medicinal preparations whose doses have been fixed and whose properties have been investigated. On this basis the author has computed the smallest doses of certain radicles given in common medical practice and their equivalent concentration in 4 kilograms of water, or a little more than a gallon—a generous day's allowance of drinking water. Consistent effort has been made to have the concentrations finally expressed represent a minimum below which therapeutic activity could not logically be attributed to the radicle in question, and every reasonable allowance has been made with that object in view. The strengths thus obtained are proposed as

[1] For further data see Dole, R. B., The concentration of mineral water in relation to therapeutic activity: U. S. Geol. Survey Mineral Resources, 1911, pt. 2, pp. 1175–1192, 1912.

standards for differentiation between medicinal and common waters, the assumption being that water which carries less than one medicinal dose of a physiologically active radicle in a day's allowance would not have therapeutic value by virtue of its mineral content. This does not necessarily imply, however, that use of such water may not be beneficial, for the improvement in health following the ingestion of hygienically pure water under proper regimen of diet, exercise, and similar factors is thoroughly recognized. On the other hand, supplies exceeding the minimum concentrations may not necessarily possess special medicinal value, as every reasonable allowance tending to lower the standards has been made.

TABLE 98.—*Minimum medicinal doses of certain radicles and their equivalent concentration in 4 kilograms of water, arranged in order of concentration.*

Radicle.	Average minimum dose.	Equivalent concentration.
	Grams.	*Milligrams per kilogram.*
Arsenite (AsO_2)	[a] 0.0002	0.2
Arsenate (AsO_4)	[a] 0.0002	.3
Fluoride (F)	.002	.5
Barium (Ba)	.003	.7
Hydroxide (OH)	.013	3
Aluminum (Al)	.011	[b] 3
Iron (Fe)	.024	6
Lithium (Li)	.075	15
Ammonium (NH_4)	.078	20
Manganese (Mn)	.12	30
Metaborate (BO_2)	[c] .035	30
Pyroborate (B_4O_7)	[c] .035	30
Iodide (I)	.12	30
Magnesium (Mg)	.2	50
Orthophosphate (PO_4)	.23	50
Carbonate (CO_3)	.281	70
Sulphite (SO_3)	.315	70
Thiosulphate (S_2O_3)	.300	70
Nitrate (NO_3)	.5	100
Bromide (Br)	.33	100
Sulphate (SO_4)	.6	150

[a] Equivalent as arsenic (As). [b] In acid solution. [c] Equivalent as boron (B).

The smallest dose of sulphates, which are laxative, recommended by various authorities is equivalent to about 0.6 gram SO_4. This amount evidently should be contained in a quantity of water that might be drunk within a comparatively short period, because otherwise the radicle would not be concentrated enough to cause perceptible reaction. Nevertheless, for consistency this dose has been divided by 4 in the tabulation of concentrations. A water containing 600 milligrams per kilogram of sulphate (SO_4) might exercise gentle laxative action. Many waters containing less than 1 milligram per kilogram of lithium are advertised as having specific curative properties by virtue of the presence of that radicle, but the therapeutic value of such a small amount of this ingredient may well be questioned, because a physician would have to prescribe 40 gallons of the water to administer an ordinary minimum dose of lithium.

Study of analyses and other data on mineral waters yields four significant facts: First, many patients have improved in health under mineral-water treatment; second, waters of widely different chemical composition have been recommended as cures for the same disease; third, curative properties are attributed to many waters whose mineral content is the same or is lower than city supplies used daily by thousands of people without peculiar physiologic effect; fourth, treatment at resorts is very often recommended for those afflicted with chronic organic diseases, many of which are obscure in nature or are caused by failure of proper interchange between food and waste in the tissues of the body. These facts lead to the reasonable conclusion that the free use of water itself—hydrogen monoxide, the common ingredient of all these mineral solutions—is the cause of much of the apparent improvement in health, and that this agent is aided by normal regimen of diet and exercise and by other hygienic restrictions, as well as by possible change of climate and freedom from business or household cares.

No doubt can be entertained that many mineral waters have distinct physiologic effect because of the inorganic substances dissolved in them, for certain obvious reactions following the ingestion of some waters differ entirely in kind or in degree from the reactions following the drinking of other waters. Some natural solutions are poisonous; some are cathartic; some have less obvious but demonstrable effects. The nature and the magnitude of these reactions are as much dependent on the nature and the concentration of the dissolved substances as the reactions caused by any medicine. As the administration of water in one or more of many ways and at various temperatures can cause marked reactions, however, it is pertinent to inquire how much of the therapeutic value of natural mineral waters is due to dissolved inorganic matter and how much to water itself.

PURIFICATION OF WATER.

GENERAL REQUIREMENTS.

Purification of water is removal or reduction in amount of the substances that render waters in their raw state unsuitable for use. It is practiced on a large scale with one or more of three objects in view: First, to render the supply safe and unobjectionable for drinking; second, to reduce the amount of the mineral ingredients injurious to boilers; third, to remove substances injurious to machinery or to industrial products. The largest purifying plants in this country have been constructed almost solely to render the waters potable; and some waters when so purified need no further treatment to make them suitable for steaming and for general industrial purposes. But many other waters are hard, and increased appreciation

of the value of good water has resulted in demand for the removal of the hardening constituents also.

Removal of bacteria, especially those causing disease, and removal of turbidity, odor, taste, and iron are the principal requirements in purification of a municipal supply, elimination of bacteria and suspended matter being the most important. The common methods of effecting such purification are slow filtration through sand and rapid filtration after coagulation, both methods usually being combined with sedimentation.[1] The first process is known as "slow sand" filtration and the second as "mechanical" or "rapid sand" filtration. The efficiency of such filters is measured primarily by the ratio between the number of bacteria in the applied water and the number in the effluent. This figure, stated in percentage of removal, should be as high as 98, and it often reaches 99.8 per cent under normal conditions with a carefully operated filter of either kind.

Removal of scale-forming and neutralization of corrosive constituents are the chief aims in preparing water for steam making. For this two general methods are employed—cold chemical precipitation followed by sedimentation and heating with or without chemicals, usually followed by rapid filtration. The first process is carried on in cold-water softening plants and the second in feed-water heaters.

METHODS OF PURIFICATION.

The requirements of the water supplies for industries are so varied that classification of purification methods is difficult. Water properly prepared for domestic and boiler use is suitable for most industrial establishments, and it is more economical for small manufacturers in large cities to obtain such water from the city mains than to maintain private supplies and purification apparatus. It is usually cheaper, however, for large factories to be supplied from separate sources, not only because of saving in actual cost of water, but also because of the opportunity thus afforded of procuring water specially adapted to the needs of the factory. The common methods of industrial water purification are those already mentioned, or combinations of them, modified to meet particular needs. In a few industrial processes, notably the manufacture of ice by the can system, water practically free from all dissolved and suspended substances is necessary, and distilled water must be manufactured. Recent improvements in multiple-effect evaporators have greatly reduced the cost of distillation, so that it is now economical to distill for industrial and domestic use many waters heretofore considered too highly mineralized for treatment. Many large factories, hotels, and even municipalities have installed multiple-effect stills.

[1] For descriptions of filters see Johnson, G. A., The purification of public water supplies: U. S. Geol. Survey Water-Supply Paper 315, 1913.

Besides the four common systems of purification many minor processes are used, sometimes alone but more frequently as adjuncts to filters or softeners. Surface waters are screened through wooden or iron grids or through revolving wire screens to remove sticks and leaves before other treatment. Coarse suspended matter can be removed by rapid filtration through ground quartz or similar material in units of convenient size provided with arrangements for washing the filtering medium similar to those used in mechanical filters. Very turbid river waters may be first allowed to stand in large sedimentation basins in order to reduce the cost of operating the filters by preliminary removal of a large part of the suspended solids. Supplies undesirable only because of their iron content are aerated by being sprayed into the air, by being allowed to trickle over the rocks, or by other methods that cause evaporation of carbonic acid and absorption of oxygen, thus precipitating and oxidizing the iron in solution so that it can readily be removed by rapid filtration. Similar aeration is employed to evaporate and oxidize dissolved gases that cause objectionable tastes and odors.

Disinfection by ozone, copper sulphate, calcium hypochlorite, and many other substances kills organisms that may cause disease or impart bad odors and tastes. Purification of this character must be done with substances that destroy the objectionable organisms without making the water poisonous to animals. Calcium hypochlorite, sodium hypochlorite, and chlorine gas are used to disinfect drinking water, and treatment with these substances is now widely practiced either as an adjunct to filtration or as an emergency precaution where otherwise untreated supplies are believed to be contaminated. Disinfection by this method is not a substitute for purification by filtration, for it does not remove suspended matter nor appreciable amounts of color, organic matter, swampy tastes, or odors, and it does not soften water.[1] Natural purification of water is accomplished largely through biologic processes,[2] in which the organic matter is oxidized by serving as food for bacteria, and objectionable organisms are destroyed by the production of conditions unfavorable to their existence. Action of this kind takes place in reservoirs and lakes, and it is also relied upon in many processes for the artificial purification of sewage.[3]

SLOW SAND FILTRATION.

Slow sand filtration consists in causing the water to pass downward through a layer of sand of such thickness and fineness that the requisite removal of suspended substances is accomplished. The

[1] Johnson, G. A., The purification of public water supplies: U. S. Geol. Survey Water-Supply Paper 315, p. 71, 1913.

[2] Hazen, Allen, Clean water and how to get it, New York, p. 83, 1907.

[3] Winslow, C.-E. A., and Phelps, E. B., Investigations on the purification of Boston sewage: U. S. Geol. Survey Water-Supply Paper 185, 1906.

slow sand filter is also called the "continuous" and the "English" filter. On the bottom of a water-tight basin, commonly constructed of concrete, perforated tiles or pipes laid in the form of a grid are covered with a foot of gravel, graded in size from 25 to 3 millimeters in diameter from bottom to top. A layer of fine sand, 3 to 4 feet deep, is put over the gravel, which serves only to support the sand. When water is applied on the surface it passes through the sand and the gravel and flows away through the underdrain. The suspended materials, including bacteria, are removed by the sand, the action of which is rendered more efficient by the rapid formation of a mat of finely divided sediment on its surface. When this film has become so thick that filtration is unduly retarded, the water is allowed to subside and about half an inch of sand is removed, after which filtration is resumed. The sand thus taken off is washed to free it from the collected impurities and is replaced on the beds after they have been reduced about a foot in thickness by successive scrapings. As cleaning necessitates temporary withdrawal of filters from service, they are divided into units of convenient size, usually one-half to 1 acre each, so that the operation of the entire system may not be interrupted. Most modern filters are roofed and sodded as this facilitates cleaning by preventing the formation of ice, permits work on the filter beds in all kinds of weather, inhibits algæ growths, and prevents agitation of the water by wind and rain.

The foregoing are the essential features of a slow sand filter, but several adjuncts render this system more efficient. A clear-water basin for the filtered supply, covered to prevent deterioration of the water, is provided in order that the varying rate of consumption may not affect the rate of filtration. Clarification of turbid water is rendered more economical by allowing it to stand for one to three days, during which a large portion of the suspended matter is deposited, so that the time between sand scrapings is lengthened. In some plants roughing, or preliminary, filters consisting of beds of coarse sand or fine crushed stone are provided, through which the water flows 15 to 20 times as fast as through the sand filters, a very large proportion of the suspended matter being thus removed. Objectionable odors and tastes may be obviated by aeration before or after filtration. Killing the bacteria before filtration by use of chlorine or other germicides is also practiced.

Slow sand filtration removes practically all the suspended matter and the bacteria. Color is only slightly reduced and hardness is not changed. The process is specially adapted to waters low in color, suspended matter, and animal pollution. Very small particles of clay are not removed by these filters, and waters carrying such particles only for short periods may be benefited by the occasional addition of a coagulant before filtration. It can readily be seen that

the efficiency of this kind of filter depends largely on the character of the sand, as the ability to prevent the passage of suspended matter is governed by the size of the spaces between the sand particles. The rate of filtration depends on the average size of the sand particles, the thickness of the sand bed, the head of the water, and the turbidity. Under ordinary conditions of operation in the United States the rate of slow sand filtration of water previously subjected to sedimentation is 2,000,000 to 4,000,000 gallons per acre per day.

RAPID SAND FILTRATION.

The rapid sand filter is also known as the American filter, and till recently it was generally styled the "mechanical" filter because of its contrivances for washing the sand. Its distinctive features are its use of a coagulant and its high rate of filtration. While the raw water is entering the sedimentation basin, which is smaller than that used with slow sand filters, it is treated with a definite proportion of some coagulant, which forms by its decomposition a gelatinous precipitate that unites and incloses the suspended material, including the bacteria, and absorbs the organic coloring matter. This combined action destroys color and makes suspended particles larger, and therefore more readily removable. When aluminum sulphate, the coagulant most commonly used, is decomposed, aluminum hydrate is precipitated and the sulphate radicle remains in solution, replacing an equivalent amount of the carbonate, bicarbonate, or hydrate radicle. One part per million of ordinary aluminum sulphate requires somewhat more than 0.6 part of alkalinity expressed as $CaCO_3$ to insure complete decomposition.[1] The natural alkalinity of many waters is sufficient to effect this reaction. If the alkalinity is not sufficient, part of the aluminum sulphate remains in solution, and good coagulation does not take place. Therefore lime or soda ash is added if the alkalinity is too low. The proper amount of aluminum sulphate to be used is determined by the amounts of color, organic matter, and suspended matter, and by the fineness of the suspended matter, and it is best ascertained by direct experimentation with the water to be purified. Much of the trouble in operating the earlier types of rapid filters has been caused by failure to produce a good "floc" or precipitation partly because of improper ratios of coagulant and alkalinity.

Ferrous sulphate instead of aluminum sulphate is used as a coagulant in some filtration plants. To this lime must be added in order to bring about proper coagulation.

The water after having been mixed with the coagulant is allowed to stand for three or four hours in the sedimentation basin, where a large proportion of the suspended particles is deposited. It is then

[1] Hazen, Allen, Report of the filtration commission of the city of Pittsburgh, p. 57, 1899.

passed rapidly through beds of sand or ground stone to remove the rest of the suspended matter. Many filters now in use are built in cylindrical form 10 to 20 feet in diameter, and some are so designed that filtration can be hastened by pressure. The sand, 30 to 50 inches deep and coarser than that used in slow sand filters, rests on a metallic floor containing perforations large enough to allow ready issue of the water but small enough to prevent passage of sand grains. When the filter has become clogged the flow of water is reversed, filtered water being forced upward through the sand to wash it and to remove the impurities, which pass over the top of the filter with the wasted water. A revolving rake with long prongs projecting downward into the sand mixes it during washing and prevents it from becoming graded into spots of coarse or fine particles. In recently constructed works rectangular filters 300 to 1,300 square feet in area have been built, in which the sand is agitated during washing by compressed air forced through it at intervals instead of by a revolving rake. Larger orifices in the strainers are also being used, the passage of sand being prevented by fine gravel over the strainer pipes. The rate of filtration is from 100,000,000 to 120,000,000 gallons per acre per day. The time between washings is 6 to 12 hours, depending principally on the turbidity of the water.

Mechanical filtration removes practically all suspended matter, reduces the color to unobjectionable proportions, and under some conditions removes part of the dissolved iron. The permanent hardness of the water is increased in proportion to the amount of sulphate added by the coagulant, and if only enough lime to decompose the coagulant is added the total hardness is slightly increased. If larger amounts of lime are added, however, the total hardness is reduced. If soda ash is used in place of lime, the foaming constituents are slightly increased. The chemicals are always added in solution. As this method of filtration is used almost entirely for river waters with fluctuating contents of suspended and dissolved matter, proper operation requires constant and intelligent attention.

COLD-WATER SOFTENING.

The principal objects of water softening are to remove the substances that cause incrustations in boilers, particularly calcium and magnesium, and to neutralize those that cause corrosion. Solutions of chemicals of known strength are added to the raw supply in such proportion as to precipitate all the dissolved constituents that can be economically removed by such treatment. The water is then allowed to stand long enough to permit the precipitate to settle, after which the clear effluent is drawn off, or the partly clarified effluent may be filtered very rapidly through thin beds of coke,

sponge, excelsior, bagging, or similar material in order to remove particles that have not subsided in the tanks. The water softeners on the market differ from each other principally in the precipitant, in the filtering medium, if one is used, and in the mechanism regulating the incorporation of the chemicals with the water. Installations may be of any size to suit consumption, and the process can be combined with rapid sand filtration for purifying municipal supplies. Among the substances that have been proposed as precipitants are sodium carbonate (soda ash), silicate, hydrate (caustic), fluoride, and phosphate; barium carbonate, oxide, and hydrate; and calcium oxide (quicklime). Lime and soda ash, however, are almost exclusively used on account of their excellent action and comparative cheapness.

When soda ash (Na_2CO_3) and lime dissolved in water to form a solution of calcium hydrate, $Ca(OH)_2$, are added to a water in proper proportion free acids are neutralized, free carbon dioxide is removed, bicarbonates are decomposed, and iron, aluminum, and magnesium hydrates and calcium carbonate are precipitated. The precipitate in settling takes down with it a large proportion of the suspended matter. The treatment removes the incrusting constituents practically to the limit of their solubility and also removes the calcium added as lime. Sodium, potassium, sulphates, and chlorides are left in solution, and the alkalies are increased in proportion to the quantity of soda ash added; that is, the foaming constituents are increased, and the maximum proportion of these that is allowable in the treated water fixes the maximum proportion of incrustants that a raw water can contain and be satisfactorily treated. The proportion of incrustants left in a treated water is determined by the solubility of the precipitated substances and by the completeness of the reaction between the added chemicals and the dissolved matter. It has been brought below 90 parts per million in some well-treated waters. The sulphate radicle can be removed by using barium compounds, which precipitate barium sulphate, but the poisonous effect of even small amounts of barium and the relatively high cost of its salts are great objections to their use. The chlorides are not changed in amount by water softening. The chemicals should be very thoroughly mixed with the raw water and sufficient time should be allowed for complete reaction, which proceeds rather slowly, for otherwise precipitation will occur later in pipe lines or in boilers.

FEED-WATER HEATING.

Water heaters are designed primarily to utilize waste heat in stationary boiler plants by raising the temperature of the feed water and thereby lessening the work of the boilers themselves, but they also effect some purification, and many heaters have been specially

designed with that end in view. The heat is derived from exhaust steam or from flue gases. Heaters utilizing steam either are open—that is, operated at atmospheric pressure—or are closed and operated at or near boiler pressure. In accordance with these different conditions, which result in distinct purifying effects, feed-water heaters are classified as "open" or "closed" or "economizers," the last being those using flue gases.

In most forms of open heaters, which are best adapted for removing large quantities of the materials that form soft scale, the steam enters at the bottom and the water at the top, and intimate contact between the two is obtained by spraying the water or by allowing it to trickle over or to splash against plates. By this process the water is quickly heated nearly to boiling temperature; dissolved gases are expelled; bicarbonates are decomposed; and iron, aluminum, part of the magnesium, and calcium equivalent to the carbonates after decomposition of the bicarbonates are precipitated as hydrates, oxides, and carbonates, under varying conditions of temperature, pressure, and time. The precipitate agglomerates the particles of suspended matter and makes them more readily removable by sedimentation and filtration. The slowness with which the reactions take place and the presence of acid radicles other than carbonates to hold the bases in solution prevent complete removal of calcium and magnesium. The addition of soda ash in proper proportion, however, effects fairly complete precipitation of the alkaline earths, and apparatus for constant introduction of this chemical in solution may be provided. Open heaters operated without a chemical precipitant remove constituents that are soft and bulky and leave those that form hard scale. Scale from water treated without chemicals in such heaters is therefore not so great in amount but is harder than that formed by the raw water.

After the precipitate has been formed the water passes through filters of burlap, excelsior, straw, hay, wool, coke, or similar materials arranged in units that can readily be cleaned.

In closed heaters the water is passed through tubes surrounded by steam or around steam pipes, and manholes or other openings are provided for removing the scale from the tubes. As the water is heated under pressure some precipitation takes place, but closed heaters are not so efficient in this respect as open heaters, because they do not permit escape of the gases liberated from the water. This objection does not hold if treatment in a closed heater follows treatment in an open one, from which the gases escape. Several systems accomplish very good purification by using a unit of each type in series.

Economizers consist essentially of water tubes set in flues leading from the furnaces. Facilities are provided for cleaning scale from

the inside and soot from the outside of the tubes. As economizers are heated by flue gases, the water in the tubes can be heated under pressure to much higher temperature than in open or closed heaters, and conditions of ordinary boiler operation are approximated. The precipitation of incrustants varies greatly with the normally fluctuating temperature of the flue gases.

CHEMICAL COMPOSITION OF SURFACE WATERS.

From October, 1906, to October, 1907, daily samples of water were collected from six rivers in Georgia by representatives of the United States Geological Survey in connection with an extensive study of the quality of surface waters of the United States. The daily samples were united in sets of 10 consecutive samples from each river and the composites thus obtained were analyzed.[1] Through the courtesy of the authorities in charge at the University of Georgia the Survey was furnished laboratory space and other facilities for the performance of these examinations till May, 1907, when the work was transferred to Survey laboratories at Norfolk, Va., and Washington, D. C.

In the following tables of analyses the first column gives the turbidity or cloudiness of the water compared with that of standard suspensions of diatomaceous earth,[2] and the second gives the weight of the suspended matter dried at 180° C. The third column is obtained by dividing the weight of the suspended matter by the turbidity. It expresses the comparative fineness of the suspended solids, a matter of much interest to operators of plants for purification of water. The last column gives the mean gage height of the river during each sample period in order that the river stage may be compared with the mineral content of the water. The next to the last column gives the weight of the total dissolved solids dried at 180° C. in distinction from that of the suspended solids. The other columns indicate the composition of the dissolved solids.

[1] For description of methods of analysis see Dole, R. B., The quality of surface waters of the United States: Part I, Analyses of waters east of the one hundredth meridian: U. S. Geol. Survey Water-Supply Paper 236, 1909.

[2] Report of the committee on standard methods for the examination of water and sewage, Am. Public Health Assoc., New York, p. 7, 1912.

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TABLE 99.—*Mineral analyses of water from Chattahoochee River at West Point.*[a]

[Parts per million unless otherwise stated.]

Date (1906–7).		Turbidity.	Suspended matter.	Coefficient of fineness.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle, (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height.
From—	To—																
																	Feet.
Oct. 20	Oct. 29	85	50	0.59	.....	16	1.0	6.6	1.2	.....	0.0	24	....	0.0	2.0	50	4.2
Oct. 30	Nov. 8	45	25	.56	.....	30	.6	3.6	.8	.....	.0	19	....	.4	2.5	60	3.4
Nov. 9	Nov. 18	65	37	.57	.....	20	.20	5.7	Tr.	.....	.0	22	....	.4	1.5	54	3.5
Nov. 19	Nov. 29	70	24	.34	.....	26	.7	6.8	1.6	.....	.0	27	....	.6	3.0	71	4.1
Nov. 30	Dec. 9	60	37	.62	.....	30	.8	6.0	2.8	.....	.0	24	....	.7	2.8	77	3.3
Dec. 10	Dec. 19	55	34	.62	.....	32	.5	6.4	2.4	.....	.0	29	....	.4	3.0	81	4.1
Dec. 21	Jan. 1	130	96	.74	.....	32	.9	3.9	Tr.	.....	.0	15	....	.7	1.5	60	4.8
Jan. 2	Jan. 11	85	65	.76	.....	24	.7	2.3	.8	.....	.0	.....	.....	.8	2.5	55	5.3
Jan. 12	Jan. 21	25	14	.56	.....	17	.10	4.7	.8	.....	.0	17	....	.8	3.5	59	3.7
Jan. 22	Jan. 31	15	9.0	.60	.....	24	.30	7.4	1.6	.....	.0	29	....	.5	3.5	59	3.5
Feb. 1	Feb. 10	220	169	.77	.....	33	1.2	3.6	1.6	.....	.0	.....	.....	.4	1.8	53	7.2
Feb. 11	Feb. 26	55	42	.76	.....	18	.9	4.8	Tr.	.....	.0	15	....	.3	....	56	3.8
Feb. 27	Mar. 8	260	205	.79	.....	25	1.3	4.4	Tr.	.....	.0	15	....	.3	1.5	53	7.7
Mar. 9	Mar. 18	290	166	.57	.....	24	.9	5.6	Tr.	.....	.0	20	....	.4	2.5	53	3.8
Mar. 19	Mar. 28	30	26	.87	.....	11	1.0	6.4	Tr.	.....	.0	22	....	.2	2.5	40	3.6
Mar. 29	Apr. 7	285	264	.92	.....	28	1.4	6.8	Tr.	.....	.0	22	....	.4	3.0	59	3.5
Apr. 8	Apr. 17	190	220	1.16	.....	27	1.1	2.0	Tr.	.....	.0	9.8	....	1.6	1.5	40	3.7
Apr. 18	Apr. 27	185	175	.95	.....	18	1.0	2.5	Tr.	.....	.0	9.8	....	1.3	2.0	33	5.9
Apr. 28	May 7	185	165	.89	.....	16	1.3	3.5	.8	.....	.0	12	....	1.1	1.5	34	4.6
May 8	May 18	350	279	.80	16	22	.03	4.9	1.1	8.8	[b]8.4	13	4.8	.9	....	57	5.1
May 19	May 28	115	76	.66	7.9	23	.03	5.2	1.9	9.2	[b]8.4	21	5.0	.9	1.3	65	3.6
May 29	June 7	260	166	.64	10	14	.03	3.0	.6	10	.0	26	4.0	1.2	1.7	47	3.7
June 8	June 17	130	91	.70	2.4	16	.03	3.2	1.1	7.2	[b]3.6	21	3.5	.0	1.0	45	3.1
June 18	June 27	120	81	.67	5.8	11	.00	5.1	1.2	6.7	.0	16	7.6	.7	1.7	42	2.8
June 28	July 7	340	246	.72	13	12	.00	4.9	.7	7.0	[b]Tr.	27	4.0	1.1	2.0	45	3.2
July 9	July 18	450	448	1.00	35	9.0	.00	4.3	.9	7.6	.0	28	3.0	1.0	1.2	36	3.0
July 19	July 28	325	214	.66	12	13	.00	4.0	1.1	8.1	.0	24	3.8	1.1	1.2	40	2.6
July 29	Aug. 7	375	289	.77	21	12	.03	6.0	1.3	9.4	.0	37	6.6	1.2	4.8	63	2.7
Aug. 8	Aug. 17	400	220	.55	10	14	Tr.	3.2	1.0	7.9	.0	24	4.0	1.1	1.8	47	2.6
Aug. 18	Aug. 27	375	242	.64	6.6	15	Tr.	4.2	.6	6.3	.0	28	4.2	1.1	2.0	48	2.6
Aug. 28	Sept. 6	225	121	.54	3.7	17	Tr.	4.9	.5	6.5	.0	27	4.8	1.0	1.8	60	2.0
Sept. 17	Sept. 26	155	129	.83	5.2	12	Tr.	5.1	.8	6.6	.0	27	4.3	.7	1.3	46	2.6
Sept. 27	Oct. 8	185	100	.54	12	18	Tr.	4.9	.4	9.0	.0	29	4.1	1.0	1.8	54	2.5
Oct. 9	Oct. 18	140	98	.70	4.4	8.9	Tr.	5.7	1.0	5.8	.0	27	3.5	.6	1.7	42	2.1
Mean.....		185	136	.71	.....	20	.47	4.8	.8	7.7	.0	23	4.5	.7	2.1	52	.....
Per cent of anhydrous residue....		.....	.....	.....	.....	38.0	[c]1.3	9.1	1.6	14.6	21.5	.....	8.5	1.4	4.0	....	.....

[a] Analyses Oct. 20, 1906, to May 7, 1907, by Jas. R. Evans; May 8 to Oct. 18, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins. Samples collected by E. N. Dunn in midstream from Montgomery Street Bridge. Gage heights measured at same place.

[b] Abnormal; computed as HCO_3 in the average.

[c] Fe_2O_3.

TABLE 100.—*Mineral analyses of water from Ocmulgee River near Macon.*[a]

[Parts per million unless otherwise stated.]

Date (1906–7). From—	To—	Turbidity.	Suspended matter.	Coefficient of fineness.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height.
																	Ft.
Oct. 19	Oct. 28	35	27	0.77	.....	12	0.6	5.6	1.6	.....	0.0	20	.....	0.1	4.0	50	3.7
Oct. 29	Nov. 7	49	14	.29	.....	32	.5	5.2	.8	.....	.0	22	.....	.5	3.0	66	2.9
Nov. 8	Nov. 17	50	18	.36	.....	30	.20	8.3	Tr.	.....	.0	27	.....	.5	1.5	77	3.0
Nov. 18	Nov. 27	65	26	.40	.....	30	.30	7.5	1.2	.....	.0	22	.....	.2	1.8	72	4.0
Nov. 28	Dec. 7	60	24	.40	.....	26	.9	8.1	1.6	.....	.0	25	.....	.6	1.5	77	2.8
Dec. 8	Dec. 17	75	46	.61	.....	29	.7	9.6	1.2	.....	.0	32	.....	.8	1.7	75	3.3
Dec. 21	Jan. 4	30	20	.67	.....	26	.9	4.4	Tr.	.....	.0	15	.....	.1	4.0	56	5.4
Jan. 5	Jan. 16	60	42	.70	.....	18	.8	3.6	Tr.	.....	.0	12	.....	.5	3.5	88	4.3
Jan. 17	Jan. 26	40	28	.70	.....	21	.8	3.6	Tr.	.....	.0	12	.....	.4	2.0	46	3.3
Jan. 27	Feb. 5	240	189	.79	.....	34	1.8	4.6	2.4	.....	.0	....	.....	.5	2.5	64	7.2
Feb. 6	Feb. 15	75	60	.80	.....	32	.8	7.6	Tr.	.....	.0	24	.....	.4	2.0	58	7.8
Feb. 16	Feb. 25	40	33	.83	.....	33	.7	8.0	1.6	.....	.0	27	.....	.3	1.5	57	4.0
Feb. 26	Mar. 7	210	178	.85	.....	38	1.4	6.8	Tr.	.....	.0	22	.....	1.2	3.5	71	8.9
Mar. 8	Mar. 17	55	46	.84	.....	15	.8	6.0	.8	.....	.0	20	.....	.6	3.0	47	5.0
Mar. 18	Mar. 27	35	27	.77	.....	14	1.0	9.6	Tr.	.....	.0	29	.....	.5	3.5	52	3.4
Mar. 28	Apr. 6	25	23	.92	.....	27	1.2	11	Tr.	.....	.0	34	.....	.7	3.5	70	3.1
Apr. 7	Apr. 16	30	29	.97	.....	23	2.1	9.2	Tr.	.....	.0	29	.....	.8	4.0	64	3.4
Apr. 17	Apr. 26	560	511	.91	.....	21	1.7	5.5	1.2	.....	.0	24	.....	1.6	2.5	48	7.7
Apr. 27	May 6	450	416	.92	.....	24	1.4	4.5	.8	.....	.0	15	.....	1.8	3.0	50	5.3
May 7	May 16	204	158	.77	.....	31	1.1	6.7	.....	10	.0	40	3.3	1.0	5.0	96	4.5
May 17	May 26	45	31	.69	.....	25	2.0	5.7	2.9	8.1	.0	43	2.0	.3	4.0	85	3.0
May 27	June 5	310	234	.75	.....	26	1.2	4.9	2.8	11	.0	....	5.9	.4	2.5	91	3.1
June 6	June 15	226	179	.79	.....	23	1.2	5.7	2.6	4.4	.0	37	4.9	.4	3.0	78	2.8
June 16	June 26	410	241	.59	.....	25	2.4	4.1	2.4	6.9	.0	31	4.8	1.1	4.0	86	2.5
June 27	July 11	670	527	.79	.....	23	2.0	6.5	1.5	6.3	.0	31	5.2	.7	3.5	84	4.3
July 12	July 21	416	331	.79	.....	32	1.6	8.1	2.2	7.5	.0	41	6.8	1.0	4.0	94	2.2
Aug. 3	Aug. 12	1,100	807	.73	21	7.5	Tr.	5.0	1.5	6.8	.0	24	4.7	1.1	1.4	35	2.7
Aug. 13	Aug. 22	580	552	.95	35	21	Tr.	5.8	1.8	11	.0	40	4.3	1.2	1.8	64	3.3
Aug. 24	Sept. 9	550	414	.75	16	16	Tr.	5.8	1.8	6.6	.0	32	4.7	1.3	2.6	53	1.7
Sept. 10	Sept. 19	270	133	.49	10	41	Tr.	6.4	2.3	7.4	.0	38	5.8	.9	1.0	87	1.1
Sept. 20	Sept. 30	400	260	.65	8.9	29	Tr.	5.1	1.8	11	.0	34	6.4	1.0	2.3	70	3.7
Oct. 1	Oct. 10	180	90	.50	2.6	42	Tr.	5.7	1.8	11	.0	37	.....	.7	3.0	85	1.6
Oct. 12	Oct. 21	35	32	.91	1.1	28	Tr.	4.7	1.4	8.1	.0	30	5.5	.6	3.2	70	.9
Mean.....		230	174	.72	.....	26	.9	6.3	1.2	8.3	.0	28	4.9	.7	2.8	69	....
Per cent of anhydrous residue....		.....	....	.....	.....	39.8	[b]2.0	9.6	1.8	12.7	21.2	....	7.5	1.1	4.3	....	....

[a] Analyses Oct. 19, 1906, to May 6, 1907, by J. R. Evans; May 7 to July 21, 1907, by W. D. Collins; Aug. 3 to Oct. 21, by R. B. Dole, Chase Palmer, and W. D. Collins. Samples collected by G. E. Lawton in midstream from bridge. Gage heights measured at same place.

[b] Fe_2O_3.

TABLE 101.—*Mineral analyses of water from Savannah River near Augusta.*[a]

[Parts per million unless otherwise stated.]

Date (1906–7). From—	Date (1906–7). To—	Turbidity.	Suspended matter.	Coefficient of fineness.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height.
																	Ft.
Oct. 25	Nov. 3	45	33	0.73	.....	21	.....	5.4	1.2	.....	0.0	27	.....	0.1	3.0	56	9.6
Nov. 4	Nov. 13	40	17	.42	.....	28	0.20	6.2	Tr.	.....	.0	24	.....	.6	3.0	77	9.0
Nov. 14	Nov. 23	35	12	.34	.....	32	.30	4.4	Tr.	.....	.0	17	.....	.7	1.5	59	10.4
Nov. 24	Dec. 3	40	17	.42	.....	32	.20	4.9	Tr.	.....	.0	20	.....	.8	1.5	64	9.2
Dec. 4	Dec. 13	55	20	.36	.....	34	.30	6.4	3.2	.....	.0	22	.....	.6	1.8	74	9.6
Dec. 14	Dec. 23	65	22	.34	.....	31	.30	6.2	2.8	.....	.0	22	.....	.5	2.0	72	10.8
Dec. 24	Jan. 2	85	55	.65	.....	36	.40	3.9	Tr.	.....	.0	15	.....	.3	3.0	78	11.0
Jan. 3	Jan. 12	60	46	.77	.....	24	.7	3.9	1.6	.....	.0	17	.....	.8	2.5	54	11.2
Jan. 13	Jan. 22	16	10	.62	.....	17	.40	6.0	4.8	.....	.0	27	.....	.8	3.0	60	9.3
Jan. 23	Feb. 2	60	41	.68	.....	30	.40	8.2	2.8	.....	.0	34	.....	.4	3.5	70	9.3
Feb. 3	Feb. 12	150	127	.85	.....	23	.7	5.4	.8	.....	.0	20	.....	.9	3.0	53	14.2
Feb. 13	Feb. 22	20	17	.85	.....	13	1.2	7.6	1.2	.....	.0	24	.....	.6	3.0	52	9.2
Mar. 13	Mar. 22	22	15	.68	.....	12	.9	5.6	Tr.	.....	.0	20	.....	.6	2.8	42	9.4
Mar. 23	Apr. 1	15	14	.93	.....	20	.9	8.4	Tr.	.....	.0	27	.....	.5	3.0	55	8.4
Apr. 2	Apr. 11	45	42	.93	.....	23	1.2	8.4	Tr.	.....	.0	27	.....	.3	2.5	59	8.5
Apr. 12	Apr. 21	210	205	.98	.....	26	1.4	7.6	Tr.	.....	.0	24	.....	.3	1.5	52	8.4
Apr. 22	May 1	340	316	.93	.....	20	1.6	5.5	Tr.	.....	.0	19	.....	.4	3.0	42	11.6
May 2	May 11	265	248	.94	.....	17	1.8	7.2	1.6	.....	.0	24	.....	.2	3.0	45	9.5
May 12	May 22	45	38	.84	3.2	37	.22	5.9	.4	13	.0	50	5.5	.8	1.7	90	8.3
May 23	June 1	130	142	1.09	5.2	31	.20	5.2	.4	13	[b]9.6	27	5.7	.7	1.8	78	8.3
June 2	June 11	175	259	1.65	14	21	.54	4.9	.4	11	[b]7.2	17	6.1	.7	1.4	61	9.8
June 12	June 21	300	231	.77	9.6	17	.08	5.1	.2	12	[b]Tr.	35	5.6	1.1	1.4	51	8.2
June 22	July 3	425	338	.79	14	15	.06	5.1	.4	11	[b]Tr.	37	5.8	1.6	1.6	54	8.8
July 4	July 13	315	255	.81	9.4	25	.20	5.0	.7	12	[b]7.2	24	5.5	.2	1.4	67	7.7
July 14	July 23	425	446	1.05	18	30	.26	5.0	.....	12	[b]14	9.8	7.3	.9	1.2	76	8.4
July 24	Aug. 3	400	419	1.05	14	14	.04	4.7	.4	13	[b]9.6	22	7.4	.0	Tr.	53	7.6
Aug. 4	Aug. 13	575	424	.74	46	15	Tr.	5.1	.6	11	.0	32	6.8	3.0	1.8	53	7.4
Aug. 14	Aug. 23	475	318	.67	28	16	.04	5.1	.5	10	[b]3.6	30	6.7	.3	1.7	56	9.5
Aug. 24	Sept. 2	160	75	.47	7.9	22	Tr.	5.0	.5	13	.0	40	6.0	1.0	2.0	63	6.5
Sept. 3	Sept. 12	270	159	.59	11	18	.04	5.0	.4	11	.0	34	5.3	1.0	2.2	58	6.8
Sept. 13	Sept. 22	200	72	.36	9.3	19	.00	6.0	.5	12	.0	40	5.8	.7	2.2	64	6.1
Sept. 23	Oct. 2	300	299	1.00	21	14	.04	6.0	.3	9.2	.0	33	4.9	.0	1.6	49	10.9
Oct. 3	Oct. 12	65	59	.91	5.6	16	Tr.	4.6	.4	9.6	.0	32	4.7	.7	1.9	53	6.3
Oct. 13	Oct. 22	25	25	1.00	2.4	21	.00	5.3	.5	11	[b]2.4	32	6.0	.0	1.8	61	5.3
Mean.....		172	142	.77	.....	23	.44	5.7	.8	12	.0	30	6.0	.6	2.1	60	....
Per cent of anhydrous residue.....		.....	.....	.....	.....	35.0	[c].9	8.7	1.2	18.3	22.6	.....	9.1	1.0	3.2	.....	.....

[a] Analyses Oct. 25, 1906, to May 11, 1907, by J. R. Evans; May 12 to Oct. 22, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins. Samples collected by C. A. Maxwell in midstream from the highway bridge. Gage heights measured at same place.

[b] Abnormal; computed as HCO_3 in the average.

[c] Fe_2O_3.

Though most of the analyses represent drainage from the region of crystalline rocks, all the streams but one traverse the Coastal Plain and probably are not greatly increased in mineral content by drainage from the sedimentary rocks. The analyses of water from Chattahoochee River at West Point, Ocmulgee River near Macon, and Savannah River near Augusta (see Tables 99–101) represent drainage essentially from silicate rocks, chiefly granite and gneiss, that contribute little mineral matter because of their slight solubility.

TABLE 102.—*Mineral analyses of water from Oostanaula River near Rome.*[a]

[Parts per million unless otherwise stated.]

Date (1906–7). From—	To—	Turbidity.	Suspended matter.	Coefficient of fineness.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height.
																	Ft.
Oct. 21	Oct. 30	25	18	0.72	....	9.6	Tr.	12	.....	.....	0.0	39	.....	0.1	2.0	63	6.1
Oct. 31	Nov. 9	40	14	.35	....	23	0.30	12	.....	.....	.0	46	.....	.6	3.0	81	2.8
Nov. 10	Nov. 19	140	120	.86	....	34	.40	9.9	.....	.....	.0	39	.....	.3	.....	79	3.3
Nov. 20	Dec. 1	125	96	.77	....	34	.6	11	1.2	.....	.0	37	.....	.4	1.5	85	14.4
Dec. 2	Dec. 11	95	69	.73	....	29	.40	9.6	.....	.....	.0	34	.....	.6	1.5	70	3.6
Dec. 12	Dec. 21	105	77	.73	....	27	.9	8.2	1.2	.....	.0	32	.....	.8	1.8	66	6.3
Dec. 22	Dec. 31	70	53	.76	....	25	.7	11	1.6	.....	.0	44	.....	.4	2.0	82	6.6
Jan. 1	Jan. 10	65	41	.63	....	22	.8	9.6	1.2	.....	.0	37	.....	.6	1.5	62	8.0
Jan. 11	Jan. 20	25	16	.64	....	14	.20	11	1.2	....	.0	37	.....	1.0	1.8	67	3.0
Jan. 21	Jan. 31	30	21	.70	....	21	.8	13	1.2	....	.0	44	.....	.2	1.5	75	3.2
Feb. 1	Feb. 10	40	28	.70	....	18	.6	11	3.2	....	.0	41	.....	.7	2.0	66	9.0
Feb. 11	Feb. 20	4	3.6	.90	....	13	.7	11	.8	.....	.0	37	.....	.3	2.0	54	3.6
Feb. 21	Mar. 4	165	124	.75	....	33	1.3	14	2.0	.....	.0	44	.....	.4	3.0	83	9.7
Mar. 5	Mar. 14	45	38	.84	....	16	.9	7.6	Tr.	.....	.0	24	.....	.4	2.0	47	6.1
Mar. 15	Mar. 24	25	23	.92	....	18	1.2	15	1.2	.....	.0	51	.....	.8	1.0	76	4.0
Mar. 25	Apr. 3	12	10	.83	....	19	1.2	11	.....	.....	.0	34	.....	.6	2.5	62	3.1
Apr. 4	Apr. 13	65	56	.86	....	17	1.4	14	3.2	.....	.0	....	.....	.4	2.0	70	3.4
Apr. 14	Apr. 23	60	56	.93	....	8.8	1.4	15	4.0	.....	.0	59	.....	.2	2.0	68	3.6
Apr. 24	May 2	260	236	.91	....	7.8	1.6	13	.....	.....	.0	51	.....	.0	3.0	61	4.7
May 3	May 13	220	220	1.00	....	18	.7	15	3.3	8.8	.0	72	2.6	.8	1.0	100	4.2
May 14	May 23	150	149	1.00	....	18	1.0	11	3.1	11	.0	72	4.3	.0	1.5	92	5.4
May 24	June 5	340	318	.93	....	29	1.6	12	3.2	11	.0	71	4.3	.6	1.5	120	5.0
June 6	June 15	200	170	.85	....	25	.6	.....	3.3	6.0	.0	74	4.8	.0	2.5	90	3.8
June 16	June 26	180	114	.63	....	28	.40	14	4.1	8.2	.0	78	3.6	.6	2.0	101	2.4
June 27	July 7	415	378	.91	....	26	1.2	12	3.7	6.6	.0	68	3.8	.7	2.0	106	2.9
July 8	July 17	370	370	1.00	....	39	.8	13	3.9	12	.0	78	5.5	.4	2.0	122	2.4
Aug. 7	Aug. 16	260	234	.90	....	31	Tr.	9.6	4.6	13	.0	73	5.1	1.0	1.0	105	1.9
Aug. 17	Aug. 26	200	198	.76	....	23	Tr.	13	2.9	9.4	.0	67	4.8	1.0	.6	87	2.0
Sept. 27	Oct. 6	125	87	.70	....	47	Tr.	7.3	3.2	7.6	.0	51	3.6	.5	1.7	109	2.6
Oct. 7	Oct. 17	45	37	.80	1.2	44	Tr.	14	5.0	7.9	.0	74	3.8	....	1.2	118	1.5
Oct. 18	Oct. 28	10	8.8	.88	Tr.	17	Tr.	11	2.9	9.1	.0	70	3.3	....	1.8	81	1.0
Mean		128	109	.80	....	24	.7	12	2.6	9.2	.0	53	4.1	.4	1.8	82	....
Per cent of anhydrous residue		....	.....	.....	....	29.6	[b]1.2	14.8	3.2	11.3	32.2	....	5.0	.5	2.2	....	....

[a] Analyses Oct. 21, 1906, to May 2, 1907, by Jas. R. Evans; May 2 to July 17, 1907, by W. D. Collins; Aug. 7 to Oct. 28, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins. Samples collected by W. M. Chambers at waterworks pumping station. Gage heights measured at same place.

[b] Fe_2O_3.

TABLE 103.—*Comparison of the average mineral content of six surface waters of Georgia with that of certain other surface waters.*

	Suspended matter.	Coefficient of fineness.	Dissolved matter.
	Parts per million.		*Parts per million.*
Average of 6 river waters of Georgia	[a] 146	0.74	66
James River, Richmond, Va	71	.96	89
Pearl River, Jackson, Miss	46	.93	59
Tennessee River, Knoxville, Tenn	156	.81	122
Cumberland River, Kuttawa, Ky	165	.92	124
Mississippi River, Memphis, Tenn	519	.97	202
St. Lawrence River, Ogdensburg, N. Y	Tr.	.....	134
Missouri River, Ruegg, Mo	1,890	1.02	346

[a] Flint River omitted.

The quantity of dissolved matter in the water of Oostanaula River near Rome (see Table 102) is notably greater than that in the other surface waters, the excess being due to solution of carbonates of

calcium and magnesium from the old crystalline limestones and dolomites in the Oostanaula basin. Yet the mineral content is not especially high and is not at all comparable with that of surface waters of the Middle West (see Table 103) from areas underlain principally by limestone, because, first, a large proportion of the basin above Rome is occupied by silicate rocks; second, the older compact crystalline limestones are dissolved by percolating waters less readily than later formations; third, the rocks have been thoroughly washed and leached by abundant rain; and, fourth, the topography favors rapid surface run-off instead of retention of water in contact with the mineralizing substances.

TABLE 104.—*Mineral analyses of water from Flint River near Albany.*[a]

[Parts per million unless otherwise stated.]

Date (1906–7).		Turbidity.	Suspended matter.	Coefficient of fineness.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).[b]	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).[c]	Nitrate radicle (NO_3)	Chlorine (Cl).	Total dissolved solids.	Mean gage height.
From—	To—															
																Ft.
Oct. 23	Nov. 1	120	64	0.53	47	.....	6.8	3.6	.....	0.0	29	.....	1.8	3.0	84	4.3
Nov. 2	Nov. 11	45	31	.69	19	0.8	11	4.8	.....	.0	51	.....	.4	3.0	80	1.8
Nov. 12	Nov. 21	17	4	.24	25	.20	11	Tr.	.....	.0	32	.....	.9	2.5	74	2.3
Nov. 22	Dec. 1	20	8	.40	27	.30	12	1.2	.....	.0	34	.....	.6	2.0	77	3.0
Dec. 2	Dec. 11	25	11	.44	33	.20	12	1.2	.....	.0	37	.....	.7	2.2	90	1.9
Dec. 12	Dec. 21	35	18	.51	34	.5	14	1.6	.....	.0	49	.....	.5	2.5	93	2.1
Dec. 22	Dec. 31	40	17	.42	20	.9	6.0	.8	.....	.0	29	.....	.8	3.0	68	3.8
Jan. 1	Jan. 11	35	20	.07	18	.8	6.2	1.2	.....	.0	22	.....	.5	3.0	62	5.4
Jan. 12	Jan. 22	20	15	.75	22	.10	8.1	.8	.....	.0	34	.....	.8	4.0	63	2.8
Jan. 23	Feb. 2	12	7	.58	16	.8	7.0	.8	.....	.0	24	.....	1.1	5.5	52	3.0
Feb. 2	Feb. 11	120	89	.74	36	.9	5.6	.8	.....	.0	22	.....	.4	2.0	66	7.9
Feb. 12	Feb. 21	60	53	.88	22	1.1	6.8	.8	.....	.0	22	.....	.7	4.0	70	5.8
Feb. 22	Mar. 3	65	45	.69	14	1.2	8.4	1.2	.....	.0	27	.....	.1	2.5	47	3.8
Mar. 4	Mar. 13	85	64	.75	18	1.4	8.8	1.2	.....	.0	29	.....	.4	3.0	54	5.8
Mar. 14	Mar. 23	40	36	.90	12	.7	6.4	.8	.....	.0	22	.....	.3	1.5	39	4.1
Mar. 24	Apr. 2	30	30	1.00	24	1.4	10	1.2	.....	.0	37	.....	.7	3.0	72	2.1
Apr. 3	Apr. 12	60	50	.83	19	.8	10	.8	.....	.0	34	.....	.3	2.5	59	3.8
Apr. 13	Apr. 22	160	156	.98	23	.9	9.5	2.5	.....	.0	34	.....	.3	2.0	60	3.6
Apr. 23	May 2	460	376	.82	27	1.3	9.0	1.6	.....	.0	34	.....	.2	3.5	66	9.4
May 3	May 12	560	.....	.....	33	2.1	7.0	1.2	.....	.0	24	.....	.1	2.0	60	7.2
Mean.....		100	58	.67	24	.86	8.8	1.4	[b]7.0	.0	31	[c]6.0	.6	2.8	67	....
Per cent of anhydrous residue[d]...		.....	.....	.....	35.8	[e]1.8	13.0	2.1	10.4	22.8	.....	9.0	.9	4.2	....	....

[a] Analyses by J. R. Evans. Samples collected by D. W. Brosnan in midstream from the county bridge. Gage heights measured at same place.
[b] Fluctuates between 2 and 10 parts. Average value about 7 parts.
[c] Fluctuates between trace and 8 parts. Average value about 6 parts.
[d] Approximate.
[e] Fe_2O_3.

TABLE 105.—*Mineral analyses of water from Oconee River near Dublin.*[a]

[Parts per million unless otherwise stated.]

Date (1906–7).		Turbidity.	Suspended matter.	Coefficient of fineness.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle. (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height.
From—	To—																
																	Ft.
Oct. 18	Oct. 27	55	23	0.42	.....	29	0.6	9.0	1.2	.....	0.0	33	.....	0.4	4.0	76	1.4
Oct. 28	Nov. 6	75	51	.68	.....	32	2.0	11	.8	.....	.0	39	.....	.4	4.0	83	.6
Nov. 7	Nov. 17	85	28	.33	.....	31	.9	8.8	1.2	.....	.0	32	.....	.7	2.0	68	.8
Nov. 18	Nov. 27	85	65	.76	.....	24	.40	8.8	1.2	.....	.0	32	.....	.1	4.0	70	1.9
Nov. 28	Dec. 7	80	52	.65	.....	26	.5	9.6	1.6	.....	.0	34	.....	.7	4.5	78	.9
Dec. 8	Dec. 17	155	94	.61	.....	31	.7	12	.....	.....	.0	49	.....	.9	4.8	89	1.7
Dec. 19	Jan. 3	160	125	.78	.....	28	1.2	8.3	.8	.....	.0	27	.....	.8	5.0	83	3.1
Jan. 4	Jan. 15	105	85	.81	.....	20	.5	5.7	Tr.	.....	.0	20	.....	.4	4.0	61	3.4
Jan. 16	Jan. 26	38	32	.84	.....	30	.9	14	4.4	.....	.0	51	.....	1.1	4.2	94	1.4
Jan. 27	Feb. 6	80	59	.74	.....	26	.8	12	.....	.....	.0	56	.....	1.2	3.0	85	4.3
Feb. 7	Feb. 18	40	36	.90	.....	22	1.0	5.6	1.2	.....	.0	20	.....	.5	5.0	60	7.5
Mar. 2	Mar. 11	240	204	.85	.....	34	1.1	7.6	Tr.	.....	.0	27	.....	.6	2.5	69	6.9
Mar. 12	Mar. 21	110	100	.91	.....	16	.6	9.6	1.2	.....	.0	32	.....	.4	2.0	50	3.2
Mar. 22	Mar. 31	35	28	.80	.....	24	1.6	12	1.6	.....	.0	41	.....	.3	4.0	73	1.6
Apr. 1	Apr. 10	75	65	.87	.....	20	1.3	9.6	1.6	.....	.0	32	.....	.2	6.5	64	1.6
Apr. 11	Apr. 24	185	176	.95	.....	20	2.4	10	2.4	.....	.0	34	.....	.4	5.0	66	3.3
Apr. 25	May 4	95	75	.79	.....	16	1.8	7.0	1.6	.....	.0	24	.....	.3	2.5	48	5.4
May 5	May 14	200	206	1.03	.....	18	2.5	10	1.6	.....	.0	34	.....	.2	4.5	61	4.0
May 15	May 24	100	69	.69	6.1	18	.42	7.8	2.2	8.4	.0	44	5.4	4.0	2.2	70	1.9
May 25	June 3	350	232	.66	15	21	Tr.	7.7	2.0	11	.0	43	6.2	1.5	2.6	68	1.4
June 4	June 13	375	220	.59	16	22	Tr.	6.6	2.2	7.9	.0	45	5.6	1.0	1.9	69	.9
June 14	June 23	400	275	.69	16	11	Tr.	6.3	2.1	8.1	.0	38	6.0	Tr.	1.4	51	1.0
June 24	July 3	230	266	1.16	12	10	Tr.	6.6	3.2	8.3	.0	34	8.1	.6	1.8	54	2.4
July 4	July 14	350	354	1.01	15	15	Tr.	6.6	1.6	9.4	.0	37	4.9	3.2	2.4	57	1.6
July 15	July 24	400	233	.58	9.6	13	Tr.	7.1	1.9	6.2	[b]4.8	27	7.5	.6	3.1	62	.8
July 25	Aug. 2	650	504	.77	28	17	Tr.	6.3	1.9	8.1	.0	34	6.3	2.3	3.4	62	2.7
Aug. 4	Aug. 13	400	266	.66	19	14	.02	5.9	1.2	7.9	.0	32	6.1	2.0	2.9	55	.9
Aug. 15	Aug. 24	425	460	1.08	34	21	Tr.	7.2	.9	10	.0	40	5.4	4.2	3.1	74	2.0
Aug. 26	Sept. 7	290	205	.71	16	18	Tr.	6.9	1.1	7.9	.0	40	5.0	.7	2.4	62	.7
Sept. 8	Sept. 17	400	328	.82	24	18	Tr.	6.4	1.1	12	.0	41	5.5	1.0	2.6	63	1.0
Sept. 28	Oct. 7	350	379	1.08	15	16	.02	11	1.7	8.3	.0	54	7.4	1.7	4.9	84	3.9
Oct. 8	Oct. 17	40	....	.....	3.5	15	.6	8.5	1.9	9.2	.0	50	7.5	Tr.	2.8	....	.4
Mean.....		208	171	.78	.....	21	.68	8.5	1.6	8.8	.0	37	6.2	1.0	3.4	68	....
Per cent of anhydrous residue.....		....	....	.....	.....	30.2	[c]1.4	12.2	2.3	12.6	26.1	.....	8.9	1.4	4.9	....	....

[a] Analyses Oct. 18, 1906, to May 14, 1907, by J. R. Evans; May 15 to Oct. 17, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins. Samples collected by W. E. Martin in midstream from the highway bridge. Gage heights measured at same place.

[b] Abnormal; computed as HCO in the average.

[c] Fe_2O_3.

The waters of Flint River near Albany and Oconee River near Dublin (see Tables 104, 105) are essentially alike in respect to quantity and proportion of dissolved matter and show very little increase of mineral content as a result of seepage from the sedimentary formations. As no reliable series of analyses of water from rivers nearer the coast are available it is impossible to state the exact effect of drainage from the later sediments, which contain some calcareous material; but in view of the relatively slight differences between the waters at Albany and Dublin and those from areas of crystalline rocks it may safely be concluded that the proportions of calcium, magnesium, and bicarbonate in surface waters nearer the coast are somewhat higher, but that the proportions of other constituents are not materially different from those of waters whose analyses are recorded.

The streams frequently carry large quantities of suspended matter, and a high proportion of it is very fine. The relatively low average content of suspended matter recorded for Flint River is due to the fact that sampling of that stream was not carried through the muddy period. Loads of finely divided silt are characteristic of rivers in the Southeastern States and are troublesome in purification plants, where, besides increasing the quantity of suspended matter to be removed, they necessitate the use of a coagulant, as the fine silts pass through slow sand filters and cloud the effluents. Therefore rapid sand filtration preceded by coagulation with aluminum sulphate has been generally adopted throughout these States in preference to slow sand filtration. The quantity and the coarseness of the silts might be expected to increase in proportion to the discharge and the velocity of the streams, but such relations are by no means regular. The crests of floods after long periods of low water carry heavy loads of suspended matter, but the loads decrease very rapidly after the crests have passed, and secondary floods do not usually bear proportionate quantities. Because of this and other irregularities the relations of discharge, load, and fineness of suspended matter in these streams can not be mathematically expressed. The same comment applies also to relations between discharge and dissolved solids, for increased discharge may be accompanied by increased or decreased content of dissolved matter.

TABLE 106.—*Average composition of the water of rivers in Georgia.*

	Parts per million.						Percentage composition of anhydrous residue.					
	Savannah River near Augusta.	Ocmulgee River near Macon.	Chattahoochee River at West Point.	Oostanaula River near Rome.	Flint River near Albany.	Oconee River near Dublin.	Savannah River near Augusta.	Ocmulgee River near Macon.	Chattahoochee River at West Point.	Oostanaula River near Rome.	Flint River near Albany.	Oconee River near Dublin.
Turbidity	172	230	185	128	100	208	----	----	----	----	----	----
Suspended matter	142	174	136	109	58	171	----	----	----	----	----	----
Coefficient of fineness	.77	.72	.71	.80	.67	.78	----	----	----	----	----	----
Silica (SiO_2)	23	26	20	24	24	21	35.0	39.8	38.0	29.6	35.8	30.2
Iron (Fe)	.44	.9	.47	.7	.86	.68	a.9	a2.0	a1.3	a1.2	a1.8	a1.4
Calcium (Ca)	5.7	6.3	4.8	12	8.8	8.5	8.7	9.6	9.1	14.8	13.0	12.2
Magnesium (Mg)	.8	1.2	.8	2.6	1.4	1.6	1.2	1.8	1.6	3.2	2.1	2.3
Sodium and potassium (Na+K)	12	8.3	7.7	9.2	7.0	8.8	18.3	12.7	14.6	11.3	10.4	12.6
Carbonate radicle (CO_3)	.0	.0	.0	.0	.0	.0	22.6	21.2	21.5	32.2	22.8	26.1
Bicarbonate radicle (HCO_3)	30	28	23	53	31	37	----	----	----	----	----	----
Sulphate radicle (SO_4)	6.0	4.9	4.5	4.1	6.0	6.2	9.1	7.5	8.5	5.0	9.0	8.9
Nitrate radicle (NO_3)	.6	.7	.7	.4	.6	1.0	1.0	1.1	1.4	.5	.9	1.4
Chlorine (Cl)	2.1	2.8	2.1	1.8	2.8	3.4	3.2	4.3	4.0	2.2	4.2	4.9
Total dissolved solids	60	69	52	82	67	68	----	----	----	----	----	----

a Fe_2O_3.

The economic value of the waters of the long rivers of Georgia is indicated in Tables 103 and 106. In Table 103 the average condition of the six Georgia waters is compared with that of certain other streams. After the heavy loads of silt have been removed they are excellent for general industrial use, being soft, usually only slightly colored, and low in scale-forming and foaming constituents. The free carbonic-acid gas that they contain may cause corrosion under some conditions of boiler operation, but that trouble can be obviated by treatment with appropriate amounts of milk of lime, by which the gas is neutralized and precipitated. Proper filtration furnishes water low in mineral content, generally low in iron, soft, and otherwise satisfactory for municipal use.

CHEMICAL COMPOSITION OF THE GROUND WATERS.

ANALYTICAL RESULTS.

About 170 analyses of ground waters from the Coastal Plain of the State have been tabulated in the county descriptions of this report. More than a third of the analyses were made by Dr. Edgar Everhart of Atlanta especially for this report, and nearly half of the others were made by him in connection with earlier investigations. The remainder, made by various chemists, have been quoted from several publications. A large number of analyses previously published in hypothetical combinations and in oxide form [1] have been recalculated to ionic form in parts per million, so that they may be more easily compared with one another and with later analyses. To obviate possible misunderstanding of the method of recomputing these it may be stated that "free carbon dioxide" reported in the original analyses includes part of what is now more commonly known as the "half-bound carbon dioxide," and the calculations have been so made as to report free carbon dioxide only when the content of carbon dioxide exceeds that necessary to satisfy the bases with the bicarbonate radicle. The computations indicate that relatively few ground waters of Georgia contain normal carbonate (CO_3), or, in other words, that nearly all contain free dissolved carbon dioxide, and though the carbonate radicle has been reported in some analyses where the radicles involving carbon dioxide were not differentiated, it is entirely probable that all the combined carbon dioxide in such waters is present as the bicarbonate (HCO_3) and that the normal carbonate is absent.

The results of the analyses in this paper are stated in parts per million, and though the amounts of water used for examination were measured by volume the mineral content is generally so low that the figures may be considered to represent milligrams per kilogram or parts per million by weight. Simplicity of computation, avoidance

[1] McCallie, S. W., Georgia Geol. Survey Bull. 15, 1908.

of fractions, and certainty of the basic unit make this decimal system especially satisfactory. As metric weights are invariably used by water analysts expression of the results in grains per gallon or a similar unit involves subsequent recalculation. Reporting the results in parts per million has been generally adopted by sanitary and research chemists and by many technical chemists, and the exclusive employment of this unit industrially is delayed only by disinclination to adapt mental processes to the decimal standard.

For the convenience of those who may desire to transform the results to other forms of expression it may be stated that multiplying the number of parts per million by 0.058 gives the equivalent in grains per United States gallon of 231 cubic inches; multiplying it by 0.07 gives the equivalent in grains per Imperial gallon; and multiplying it by 0.00833 gives the equivalent in pounds per thousand gallons.

The analytical methods commonly employed in examining water permit the estimation of the elements and radicles present, the determination of the total amount of mineral matter in solution, and the more or less approximate separation of the incrusting from the non-incrusting constituents. Further than this, however, ordinary chemical tests give little knowledge regarding the chemical composition of mineral waters, and consequently the exact amounts of the different salts in solution are largely conjectural. Though such salts as sodium chloride, potassium carbonate, and magnesium sulphate are probably present, they are not determined as such, and their exact amounts can not be computed from the analytical data. The ionic form of stating the analyses—that is, stating the radicles present—has been adopted in this report because it gives fact and not opinion. The form is entirely practical and presents the actual results for the consideration and criticism of persons other than those making the tests, besides making it possible properly to compare analyses performed by different chemists.

The waters have been classified in respect to their character and value for various technical uses by application of formulas and ratings already discussed. (See pp. 471 to 487.) Though the ratings reflect the result of experience in Georgia and elsewhere they are largely opinions useful in describing the waters to persons unaccustomed to interpreting analyses, and consequently they should be sharply differentiated from the figures of the analyses, which express facts regarding the mineral constituents.

RELATION OF QUALITY TO WATER-BEARING STRATA

PRINCIPAL WATER-BEARING STRATA.

The composition of the water-bearing rocks is almost everywhere the chief determining factor in the composition of ground waters, and this is generally true throughout Georgia. Because of this an attempt has been made to ascertain the relation between the quality of the waters and the strata from which they come by grouping waters from the same formation in so far as Stephenson and Veatch have differentiated the waters in that respect. The principal water-bearing strata and their lithologic characteristics have been plainly summarized in the table of geologic formations (p. 57). Those concerning the composition of whose waters appreciable information is at hand comprise the arkosic sands of the Lower Cretaceous, the Ripley formation of the Upper Cretaceous, the Midway formation, the Claiborne group, and the Jackson formation of the Eocene, and the Vicksburg, Chattahoochee, and Alum Bluff formations of the Oligocene, and undifferentiated Oligocene to Pleistocene deposits. Other formations yield water, but the number of analyses of water from them is insufficient for proper discussion. In addition to the analyses grouped as described, the Eocene and the Oligocene are represented by a few analyses of waters whose source can not be assigned to a single formation either because the waters are derived from several strata or because their exact source is unknown; these analyses have therefore been grouped in two tables, one of waters from undifferentiated Eocene strata and the other of waters from undifferentiated Oligocene strata. A third table comprises analyses of waters from extensive but unnamed deposits now classified as "undifferentiated Oligocene to Pleistocene, inclusive." (See p. 132.)

Consideration of the conditions under which samples of water are collected makes it evident that definite conclusions regarding the chemical composition of the waters from the several water-bearing strata must be drawn with extreme caution. It is by no means certain that water from a well is a fair average sample from a single sharply differentiated stratum; indeed it is certain that the water in many wells in Georgia comes from two or more beds. As the primary purpose of the well driller is to obtain an abundant supply he usually does not attempt to shut out any water he may encounter, except possibly that near the surface if it is known to be polluted. Consequently a deep well that penetrates more than one water-bearing stratum is likely to yield a mixture, and though one kind of water may predominate the other kinds modify its quality by decreasing or increasing its mineral content. Even if all the supplies but one were excluded during construction subsequent deterioration of the casing may cause holes and cracks through which they could enter.

An instance of such admixture is afforded by conditions at Grinnell, Iowa, where highly mineralized water from the Carboniferous has entered well casings through cracks and mingled with the more desirable supplies derived from underlying formations.[1] It is possible also that wells drawing water from one stratum may not afford samples that are typical of that stratum over a wide area, as seepage from other strata may cause local changes in character. The water of shallow wells is intermittently modified by the diluting effect of rain, and deep wells may be indirectly but appreciably affected by similar dilution. Last but not by any means least important is the recognized fact that the draft on a well affects the quality of the water, for it has been observed that water from most new wells contains more mineral matter than that from the same wells after they have been used for some time or after they have been subject to heavy draft. Long-continued heavy pumping of some wells, however, has resulted in increased mineral content, this phenomenon being particularly observed in wells near the seacoast, where excessive draft has lowered the water plane and thereby permitted entrance of sea water. After consideration of all these factors that may influence mineral content it can readily be understood that statements regarding the quality of the waters should not be interpreted too literally, and it is not surprising to find great differences in the chemical composition of supplies apparently from the same bed.

LOWER CRETACEOUS SERIES.

The Lower Cretaceous is not differentiated into formations. It outcrops in a narrow belt extending across the State from Augusta southwestward to Columbus, and it rests on the crystalline rocks. It consists of coarse-grained arkosic sands with lenses of clay, some of which approach kaolin in composition. As the sands are composed largely of angular unweathered or slightly weathered fragments of silicate rocks they may be expected to yield relatively little mineral matter to percolating waters, and this expectation is corroborated to a great extent by the relatively few analyses in Table 107. The waters from the Lower Cretaceous near Macon, Walden, Toomsboro, and Tennille are very low in mineral content, and those from the wells at Gibson and Oconee appear to be normal. The town well at Sandersville undoubtedly draws from the marls and limestones of the Claiborne group (Eocene), which overlies the Cretaceous at that place, as well as from the arkosic sands, and Mr. Cohen's well probably produces a similar mixture; consequently the waters from those two can hardly be considered fair representatives of supplies from the Lower Cretaceous, but may be cited as examples of waters altered

[1] Norton, W. H., and others, Underground water resources of Iowa: U. S. Geol. Survey Water-Supply Paper 293, p. 94, 1912.

by supplies from overlying strata. The well at Columbus is said to be entirely in the Lower Cretaceous except for 20 or 30 feet of overlying Pleistocene (see p. 354), and it is therefore surprising to find the water in it so distinctly different from that of other wells drawing from the arkosic sands. Possibly the mineral content of this and similar wells at Columbus would be decreased by increased and continued draft.

In general the waters from the arkosic sands of the Lower Cretaceous may be said to range in mineral content from 20 to 130 parts per million and in hardness from 5 to 90 parts. They contain too small quantities of scale-forming ingredients to render treatment necessary before their use in boilers, and, except a few that are high in iron, they are excellent for domestic use. Next to purified river water they afford the softest and most desirable supplies for domestic and general industrial use in the State. The figures in the lowest line of Table 107 represent a roughly approximate average intended to convey numerically a very general idea of the character of water from the arkosic sands of the Lower Cretaceous in Georgia.

TABLE 107.—*Chemical composition of water from the Lower Cretaceous arkosic sands.*

[Parts per million except as otherwise designated.]

County.	Location.	Owner or source.	Depth of well.	Depth to principal water-bearing stratum.	Date of collection.
			Feet.	*Feet.*	
Glascock	Gibson	City	151	150–151	May 31, 1911
Washington	Oconee	do	140	120–140	Apr. 24, 1911
Do	Sandersville	do	436	70–325?	
Do	do	L. D. Cohen	400±	400±	Apr. 24, 1911
Do	Tennille	Town	990	380–426	Do.
Wilkinson	Toomsboro	do	315	285, 315	Dec. 16, 1912
Bibb	Macon, 7 miles east of.	Mary R. Edwards (White Elk Spring).	.....	.....	
Do	do	do	.....	.....	Dec. 30, 1912
Do	Near Walden	J. B. Willis	265	250–265	
Muscogee	Columbus	Well No. 35 of proposed city supply.	282	100–232	Mar. 27, 1911

County.	Analyst.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).
Glascock	Edgar Everhart	41	4.0	9.0	1.0	15		.....	74	6.0
Washington	do	16	1.0	29	3.0	14		0.0	110	8.0
Do	do	27	[a]10	75	2.7	9.6	1.9	125	.....	4.2
Do	do	38	.2	60	6.0	8.0		.0	234	5.0
Do	do	19	1.0	4.0	2.0	6.0		.0	12	Tr.
Wilkinson	do	16	[b]4.0	18	2.4	8.0		.0	54	13
Bibb	J. F. Sellers	1.5	.18	1.3	.2	2.0	.2	.....	5.2	3.1
Do	Edgar Everhart	6.0	.5	1.5	1.2	3.5		.0	5.0	4.0
Do	A. M. Lloyd	8.8	[a]2.5	1.6	.5	1.6	1.0	3.9	.....	1.2
Muscogee	Edgar Everhart	52	1.0	37	6.8	47		.0	88	75
Approximate average.[c]		20	.....	10	2	10		0	45	5

[a] $Fe_2O_3+Al_2O_3$. [b] Fe+Al. [c] Three strongest waters omitted.

TABLE 107.—*Chemical composition of water from the Lower Cretaceous arkosic sands*—Continued.

County.	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Total hardness as $CaCO_3$.[a]	Probable scale-forming ingredients.[a]	Probable foaming ingredients.[a]	Probability of corrosion.[a b]	Quality for boiler use.	Mineral content.	Quality for domestic use.
Glascock	0.1	4.0	121	27	70	40	N. C.	Good	Low	Fair.
Washington	Tr.	3.5	134	85	110	40	N. C.	Fair	do	Good.
Do	.....	6.8	[c] 264	199	250	30	N. C.	Poor	Mod	Poor.
Do	.2	3.5	234	175	220	20	N. C.	...do...	...do...	Good.
Do	.5	12	65	18	30	15	(?)	Good	Low	Do.
Wilkinson	Tr.	5.0	94	55	70	20	(?)	...do...	...do...	Do.
Bibb	.....	.8	[d] 16	4.0	5	5	N. C.	...do...	...do...	Do.
Do	5.0	2.0	21	8.7	15	10	(?)	...do...	...do...	Do.
Do	.....	1.6	[e] 23	6.0	15	10	N. C.	...do...	...do...	Do.
Muscogee	.0	38	314	120	170	130	(?)	Fair	Mod	Do.
Approximate average.[f]	.....	5	75	35	.....	.....	.....	.....	.....	

[a] Computed.
[b] N. C.=noncorrosive; (?)=uncertain or doubtful.
[c] PO_4 trace.
[d] Al 0.2 part; free CO_2 0.8 part.
[e] Volatile matter 0.5 part.
[f] Three strongest waters omitted.

UPPER CRETACEOUS SERIES.

The Upper Cretaceous includes two water-bearing formations, the Ripley at the top and the Eutaw at the bottom, but, as few data are available regarding the quality of the water from the Eutaw, the following discussion is confined chiefly to the waters derived from the Ripley, which comprises the Providence sand member at the top, the typical marine beds in the middle, and the Cusseta sand member at the bottom. The marine beds consist of calcareous, micaceous sand, sandy clay, and shell marl with nodular layers of calcareous sand or sandy limestone, but the Providence and Cusseta members, form which most wells are supplied, consist essentially of sand and clay with little or no calcareous material. Thus the waters come into contact with relatively little calcareous material, though they are generally of the calcium carbonate type and somewhat higher in mineral content than those in the arkosic sands of the Lower Cretaceous.

Wells draw from these beds in the area between Chattahoochee and Ocmulgee rivers southeast of Columbus and north of Albany. Twenty-eight analyses of water that come wholly or chiefly from the Ripley, according to the studies of Stephenson and Veatch, are grouped in Table 108 by counties from north to south. Their waters range widely in mineral content and in hardness. Those in Houston County of which analyses are recorded are much like those from the Lower Cretaceous arkosic sands. Over the greater part of the area where the Ripley is entered, however, the waters range from 90 to 250 parts in dissolved solids and from 20 to 140 parts in hardness. Most of them are low in iron, chlorine, and sulphate, the latter

radicle exceeding 25 parts in only two waters. The range in mineral content is most probably due to differences in the lithologic character of the water-bearing strata and to differences in the rate of diffusion from overlying strata. As the beds of the Ripley comprise sands, clays, and marls not uniformly distributed either geographically or stratigraphically local differences in mineralization may be expected; thick beds of sand containing little calcareous material would yield soft waters, whereas beds of sand containing much marl would yield hard waters. Tertiary strata 20 to 500 feet thick, including impure limestones and marl, overlie the greater part of the area where wells draw from the Ripley, and entrance of water from these overlying beds either by seepage or through intentional or accidental perforations of the casings could markedly alter the character of the supply. The water of the springs near Lumpkin, which is exceptionally low in mineral content, comes from the Providence sand member of the Ripley. In the same county, two wells 334 and 425 feet deep, which yield waters that are similar to each other and are much more strongly mineralized than the spring water, are believed to be supplied chiefly from the Ripley, which is overlain by the marls and limestones of the Midway formation. Well No. 4, at Americus, the principal water-bearing stratum of which is between 962 and 992 feet, yields water similar to that of well No. 1 and probably derives most of its supply from the Ripley. (See analysis, p. 400.) No explanation is apparent for the high mineral content of water from the 1,320-foot stratum of city well No. 2 at Albany, which differs essentially from all other waters from the Cretaceous of Georgia that have been analyzed. The upper strata of the same well, assigned to the Ripley, yield normal water. The only other well whose water approaches it in character is the 350-foot well at Eufaula, Ala.

The lowest three lines of Table 108 give the approximate average composition of waters from the Ripley and roughly the range of their constituents. In estimating these amounts the analyses of water from the 1,320-foot stratum at Albany, the 350-foot well at Eufaula, and the springs near Lumpkin have been omitted, because they are so noticeably different from the others. The figures representing average and range of constituents should therefore be interpreted broadly as numerical indications of conditions revealed by the analyses. The average represents especially conditions in the more porous sandy strata of the Ripley formation, as there is some evidence that the typical marine beds yield more strongly mineralized waters.

Most of the waters of the Ripley are fit for domestic use, being moderate in mineral content and not too hard, though some are high enough in iron to taste unpleasant and to stain fabrics washed in them. The waters are low in foaming ingredients and probably noncorrosive in boilers, though the hydrogen sulphide reported in so

many waters may cause trouble. The scale-forming ingredients range from quantities too small to cause appreciable deposits to quantities that might profitably be removed by softening plants before the waters are used in boilers.

TABLE 108.—*Chemical composition of water from Ripley formation (Upper Cretaceous).*

[Parts per million except as otherwise designated.]

County.	Location.	Owner or source.	Depth of well.	Depth to principal water-bearing stratum.	Date of collection.
			Feet.	*Feet.*	
Houston	Fort Valley	Town well No. 2	400	.....	May 20, 1911
Do	Myrtle, 1½ miles northeast of.	Norwood Spring	.....	.....	Do.
Do	Perry	Town well	138	136–138	
Do	Perry, 4¾ miles southwest of.	Southern Mortgage Co	381	376–381	May 30, 1911
Macon	Montezuma	City well	375	375	Apr. 21, 1911
Do	....do	City wells	500	500	
Do	Montezuma, 6 miles north of.	C. L. De Vaughn	125	125	Do.
Do	Oglethorpe	Town well	500	500	
Marion	Buena Vista, 1 mile northwest of.	City spring	.....	.....	Apr., 20, 1911
Schley	Ellaville	Town well	600	.....	Jan. 24, 1913
Sumter	Americus	City well No. 1	337	.....	Apr. 19, 1911
Crisp	Cordele	Town well	735	735	Apr. 18, 1911
Stewart	Lumpkin, 1 mile southwest of.	Town springs	.....	.....	May 5, 1911
Do	Richland	Town well	425	.....	Mar. 28, 1911
Do	Lumpkin, 3½ miles east of south of.	C. H. Humber	334	290	Jan. 13, 1913
Terrell	Dawson	New town well	447	.....	Mar. 29, 1911
Do	....do	Old town well	660	.....	
Dougherty	Albany	City well No. 2	1,320	[a] 660–710	
Do	....do	....do	1,320	[b] 1,320	
Do	Albany, 201 Commerce St.	City well	840	840	June 10, 1911
Do	Albany	Atlantic Ice & Coal Co	710	660	Apr. 1, 1911
Calhoun	Arlington	Town well	1,173	640	May 1, 1911
Do	Edison	....do	563	550	May 5, 1911
Do	Leary, 4 miles south of	Harper Daniel	778	650	May 8, 1911
Early	Blakely	Town well	812	812	
Clay	Fort Gaines	....do	650	.....	
Do	....do	....do	264	264	June 5, 1911
Barbour	Eufaula, Ala., [c] 1 mile southeast of.	Moulthrop's brickyard	350	20–350	

County.	Analyst.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).
Houston	Edgar Everhart	29	3.0	2.0	1.0	5.0		0.0	12	5.0
Do	....do	5.5	1.5	2.0	1.0	3.0		.0	10	7.0
Do	W. H. Hollingshead	8.5	5.5	4.4	1.3	6.1	Tr.	.....	.....	7.8
Do	Edgar Everhart	10	2.0	4.0	1.0	4.0		.0	24	9.0
Macon	....do	42	.4	14	2.0	6.0		.....	50	5.0
Do	....do	40	[d] 3.1	13	1.5	22	5.3	.0	35	12
Do	....do	20	18	6.4	1.6	8.0		.0	38	.0
Do	H. C. White	2	.....	6.7	3.2	40		.....	10	67
Marion	Edgar Everhart	5.4	.2	5.6	6.8	21		.0	12	Tr.
Schley	....do	23	5	17	4	9		.0	25	48
Sumter	....do	16	.4	46	2.0	5.0		.0	171	Tr.
Crisp	....do	39	1.2	46	5.2	5.8		.0	195	6.4
Stewart	....do	4.0	Tr.	2.0	.5	5.0		.0	12	Tr.
Do	....do	24	1.1	47	4.4	7.2		.0	178	11
Do	....do	23	4	50	4.0	14		.0	198	12
Terrell	....do	27	.4	39	6.0	14		.0	176	12
Do	....do	23	[d] .6	43	3.4	7.6	1.4	.....	120	24

[a] Second and principal water-bearing stratum.
[b] Third water-bearing stratum.
[c] Entered under Quitman County.
[d] $Fe_2O_3+Al_2O_3$.

TABLE 108.—*Chemical composition of water from Ripley formation (Upper Cretaceous)*—Continued.

County.	Analyst.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).
Dougherty	H. C. White	9.3	[a] 2.6	46	1.9	2.4		.....	140	7.1
Do	Edgar Everhart	14	[a] 1.8	4.3	1.8	463	29	576	.....	1.4
Do	....do	22	4.0	5.0	3.0	60		7.0	160	25
Do	....do	16	1.0	13	6.8	41		.0	178	14
Calhoun	....do	25	.4	10	3.0	57		10	150	12
Do	....do	17	.2	37	2.0	8.0		2.0	134	10
Do	....do	18	.6	44	5.0	17		7.0	190	8.0
Early	....do	8.0	a.7	5.4	2.0	42	9.1	.0	114	11
Clay	....do	16	[a] 3.6	7.0	1.4	76	9.1	98	.....	9.4
Do	....do	30	Tr.	10	Tr.	67		2.0	190	11
Barbour	Pratt Laboratory	16	[b] 1.9	3.5	.8	137	3.0	.....	351	5.2
Approximate average		20	3	20	3	20		.....	120	10
Approximate range:										
Highest		40	20	50	10	80		.....	200	70
Lowest		2	Tr.	2	Tr.	3		.....	10	Tr.

County.	Nitrate radicle (NO_3).	Chlorine (Cl).	Phosphate radicle (PO_4).	Volatile and organic matter.	Total dissolved solids.	Total hardness as $CaCO_3$. [c]	Probable scale-forming ingredients. [c]	Probable foaming ingredients. [c]	Probability of corrosion. [c d]	Quality for boiler use.	Mineral content.	Chemical character.	Quality for domestic use.
Houston	0.5	5.0	.....	.....	63	9	40	15	N.C.	Good..	Low ..	$Na-CO_3$	Good.
Do	.2	5.0	.....	.....	40	9	15	10	(?)	...do ..	...do ..	.....	Do.
Do	.....	2.2	2.1	.....	[e] 57	16	20	15	.....	...do ..	...do ..	$Na-CO_3$	Fair.
Do	Tr.	4.5	.....	.....	43	14	20	10	N.C.	...do ..	...do ..	.....	Good.
Macon	.1	4.0	.....	.....	110	43	90	15	(?)	...do ..	...do ..	$Ca-CO_3$	Do.
Do	.....	6.8	2.4	.....	[f] 138	39	80	70	(?)	...do ..	...do ..	$Na-CO_3$	Do.
Do	1.5	2.5	.....	.....	132	23	40	20	N.C.	...do ..	...do ..	$Ca-CO_3$	Poor.
Do	.....	27	.....	7	158	30	30	110	C.	Poor ..	Mod ..	$Na-SO_4$	Good.
Marion	50	20	.....	.....	103	42	30	60	C.	...do ..	Low ..	.....	Do.
Schley	Tr.	4	.....	.....	92	59	80	25	(?)	Good..	...do ..	$Ca-SO_4$	Fair.
Sumter	Tr.	3.5	.....	.....	170	123	160	15	N.C.	Fair ..	Mod ..	$Ca-CO_3$	Good.
Crisp	.....	5.5	.....	.....	261	136	180	15	N.C.	...do ..	...do ..	...do ...	Do.
Stewart	1.2	2.5	.....	.....	.....	7	10	15	N.C.	Good..	Low ..	.....	Do.
Do	3.0	4.0	.....	.....	209	135	170	20	N.C.	Fair...	Mod ..	$Ca-CO_3$	Do.
Do	.1	3	.....	.....	211	141	180	40	N.C.	...do ..	...do ..	...do ...	Fair.
Terrell	.4	3.0	.....	.....	202	122	150	40	N.C.	...do ..	...do ..	...do ...	Good.
Do	.....	8.2	.....	.....	174	121	160	25	(?)	...do ..	...do ..	...do ...	Do.
Dougherty	.2	3.6	.....	7.8	160	123	150	5	(?)	...do ..	...do ..	...do ...	Do.
Do	.....	69	Tr.	.....	1,159	18	30	1,330	N.C.	Very bad.	High..	$Na-CO_3$	Bad.
Do	.4	4.0	.....	.....	174	25	40	160	N.C.	Good..	Mod ..	...do ...	Fair.
Do	1.2	3.5	.....	.....	193	60	70	110	N.C.	...do ..	...do ..	...do ...	Good.
Calhoun	.1	10	.....	.....	233	37	60	150	N.C.	...do ..	...do ..	...do ...	Do.
Do	.1	4.0	.....	.....	162	101	130	20	N.C.	Fair...	...do ..	$Ca-CO_3$	Do.
Do	.2	7.5	.....	.....	186	130	160	50	N.C.	...do ..	...do ..	...do ...	Do.
Early	.....	14	Tr.	.....	[g] 140	22	30	140	N.C.	Good..	Low ..	$Na-CO_3$	Do.
Clay	.....	20	6.3	.....	248	23	40	230	N.C.	Fair...	Mod ..	...do ...	Do.
Do	.....	12	.....	.....	238	25	60	180	N.C.	...do ..	...do ..	...do ...	Do.
Barbour	.....	14	.....	33	387	12	30	380	N.C.	Poor ..	...do ..	...do ...	Do.
Approximate average.	.....	8	.....	.....	150	.....	.....	.....	.....	.....	.....	.....	
Approximate range:													
Highest	.....	30	.....	.....	260	.....	.....	.....	.....	.....	.....	.....	
Lowest	.....	2	.....	.....	40	.....	.....	.....	.....	.....	.....	.....	

[a] $Fe_2O_3 + Al_2O_3$.
[b] Fe + Al.
[c] Computed.
[d] C=corrosive; N. C.=noncorrosive; (?) =uncertain or doubtful.
[e] Al 2.8, Li trace, Zn 9.4 parts.
[f] Free CO_2, 2.0 parts.
[g] Free CO_2, 55 parts.

Analyses are available of only two waters known to be derived from the Eutaw formation and these are entered in Table 109. A larger number of analyses would undoubtedly show that the waters of this aquifer are similar in composition and usefulness to those of the sandy members of the Ripley formation, which comprise beds of similar lithologic character.

TABLE 109.—*Chemical composition of water from the Eutaw formation (Upper Cretaceous).*

[Edgar Everhart, analyst. Parts per million except as otherwise designated.]

	1	2
Depth of well (feet)	385	270
Depth to principal water-bearing stratum (feet)	110	270
Date of collection	Mar. 28, 1911.	June 4, 1911.
Silica (SiO_2)	40	26
Iron (Fe)	16	.2
Calcium (Ca)	2.4	12
Magnesium (Mg)	2.8	.5
Sodium and potassium (Na+K)	6.0	62
Carbonate radicle (CO_3)	.0	7.0
Bicarbonate radicle (HCO_3)	37	170
Sulphate radicle (SO_4)	22	23
Nitrate radicle (NO_3)	2.0	.2
Chlorine (Cl)	3.5	5.0
Total dissolved solids	126	197
Total hardness as $CaCO_3$ [a]	17	32
Probable scale-forming ingredients [a]	50	60
Probable foaming ingredients [a]	15	170
Probability of corrosion [a]	Noncorrosive.	Noncorrosive.
Quality for boiler use	Good.	Good.
Mineral content	Low.	Moderate.
Chemical character	$Na-SO_4$.	$Na-CO_3$.
Quality for domestic use	Poor.	Good.

[a] Computed.

1. Well of Mrs. L. W. Adams, 5 miles northwest of Cusseta, Chattahoochee County.
2. Well of W. C. Bradley, 5 miles north of Omaha, Stewart County.

EOCENE SERIES.

MIDWAY FORMATION.

The Midway, comprising ferruginous sand and local beds of clay together with marl, calcareous quartzite, and limestone that is generally highly arenaceous, outcrops in a narrow belt in the southwest part of the State west of Ocmulgee River. The analyses of water in Table 110 are too few to permit many general statements regarding the character of the supplies, but they are apparently similar in composition and concentration to those from the Ripley—moderately mineralized, moderate in their content of scale-forming ingredients, not likely to foam nor cause corrosion in boilers, and, except those that carry much iron, entirely acceptable for domestic use.

TABLE 110.—*Chemical composition of water from the Midway formation (Eocene).*

[Edgar Everhart, analyst. Parts per million except as otherwise designated.]

	1	2	3	4
Depth of well (feet)	Spring.	265	410	485
Depth to principal water-bearing stratum (feet)		240–265	400–410	
Date of collection	Apr., 1910.	Apr. 20, 1911.		June 1, 1911
Silica (SiO_2)	4.4	27	27	18
Iron (Fe)	7.0	3.0	[a] 4.6	4.0
Calcium (Ca)	2.5	34	47	47
Magnesium (Mg)	1.2	3.0	1.4	6.0
Sodium (Na)	5.6	8.0	4.8	13
Potassium (K)	2.6		1.9	
Carbonate radicle (CO_3)	.0	.0		.0
Bicarbonate radicle (HCO_3)	26	134	134	200
Sulphate radicle (SO_4)	.7	6.0	12	8.0
Nitrate radicle (NO_3)		1.5		.5
Chlorine (Cl)	12	3.5	5.4	4.0
Total dissolved solids	[b] 50	179	174	208
Total hardness as $CaCO_3$ [c]	11	97	123	142
Probable scale-forming ingredients [c]	15	130	170	170
Probable foaming ingredients [c]	20	20	20	40
Probability of corrosion [c]	Noncorrosive.	Noncorrosive.	Uncertain.	Noncorrosive.
Quality for boiler use	Good.	Fair.	Fair.	Fair.
Mineral content	Low.	Moderate.	Moderate.	Moderate.
Chemical character		$Ca-CO_3$.	$Ca-CO_3$.	$Ca-CO_3$.
Quality for domestic use	Fair.	Good.	Fair.	Fair.

[a] $Fe_2O_3+Al_2O_3$. [b] Al 0.5 part; free CO_2 41 parts. [c] Computed.

1. Spring of Ida Munro, ¾ mile west of Putnam, Marion County.
2. Well of Clark & Spann, Plains, Sumter County.
3. Town well, Shellman, Randolph County.
4. Well of Callahan-Powell Co., 6½ miles east of Blakely, Early County.

CLAIBORNE GROUP.

The Claiborne group comprises at the top the Barnwell sand, which consists of beds of marine sand, thin beds of silicified limestone or chert, sandstone, and quartzite, and at the bottom the McBean formation, which is mainly sand or clayey marl, sandy clay, and fuller's earth. Though the beds of the Claiborne group extend across the State, nearly all the Claiborne waters of which analyses are available are from wells in the northeastern part of the Coastal Plain, one well in Ware County and one in Clay County being the only exceptions. Three spring waters from the Claiborne (see Table 111) are very low in mineral content, but the other waters from this group range from 150 to 250 parts per million in total solids and from 90 to 160 parts in total hardness; in other words, they are moderately mineralized hard calcium carbonate waters rather high in scale-forming ingredients, but not likely to foam or be corrosive in boilers. They may be classed as generally fair for boiler use and good for domestic use. Some are reported to contain hydrogen sulphide but not in sufficient quantity to render them nauseating. These analyses are typical of waters from strata containing large proportions of calcareous material. As the waters from the Claiborne at Davisboro are not essentially different from those believed to come from the Lower Cretaceous at Oconee and Sandersville in the same county, it is possible that the calcareous waters of the Claiborne have essentially modified the purer

supplies of the Cretaceous. The water from the well in the Claiborne at Beach is like that from the Jackson at Waycross in the same county.

TABLE 111.—*Chemical composition of water from the Claiborne group (Eocene).*

[Parts per million except as otherwise designated.]

County.	Location.	Owner or source.	Depth of well.	Depth to principal water-bearing stratum.	Date of collection.
			Feet.	*Feet.*	
Richmond	9 miles south of Augusta	Windsor Spring, W. H. T. Walker.			June, 1909
Burke	1 mile northeast of Shell Bluff.	Cox Spring			1907
Do	Waynesboro	Southern Cotton Oil Co	200		
Screven	3 miles northeast of Mears.	Mears & Sanders	470	371	Apr. 25, 1911
Jenkins	Millen	City well		565	
Do	Perkins	W. E. Rushing	500	±300	June 3, 1911
Jefferson	Avera	T. S. Ivey; Omaha Spring			Do.
Do	Louisville	Well at fair grounds		200-300	
Do	Wadley			170-330	
Washington	Davisboro	Town well	325	88-325	
Do	4 miles west of Davisboro.	Spring of W. J. Henderson			Apr., 1909
Johnson	Wrightsville	Town well	[a] 409	170, 409	Apr. 30, 1911
Do	do	do	578	430, 578	
Ware	Beach	McMillan & Co	850	850	Dec. 17, 1912
Clay	Bluffton	J. E. Mansfield	60	60	June 1, 1911
Do	do	Town spring			Do.

County.	Analyst.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).
Richmond	H. C. White	3.9	[b] 0.2	3.4	0.6	0.8	0.4	0.0	12	1.6
Burke	Edgar Everhart	7.4	2.8	50	1.3	1.6	.8	.....	161	.5
Do	do	16	[b] 6.1	62	2.0	3.6	1.7	.0	201	3.7
Screven	do	28	1.0	44	2.0	14		.0	156	6.0
Jenkins	do	38	[b] 1.2	40	3.6	5.6	2.4	.....	132	11
Do	do	11	.5	64	1.0	4.0		.0	183	26
Jefferson	do	5.0	.4	1.0	1.0	2.0		.0	8.0	1.0
Do	do	39	[b] 4.1	33	1.4	3.1	2.8	47	.....	9.4
Do	do	13	[b] 1.8	57	3.1	8.9	3.0	.0	191	11
Washington	do	13	[b] 4.0	59	1.8	14	3.7	105	.....	7.2
Do	do	17	[b] .6	56	.9	1.6	.6	.0	173	1.4
Johnson	do	25	4.0	58	2.0	5.0		.0	207	Tr.
Do	H. C. White	13	2.3	62	2.2	5.4		.0	190	15
Ware	Edgar Everhart	44	3.0	33	16	25		.0	193	27
Clay	do	12	.2	47	2.0	14		2.0	158	8.0
Do	do	36	.4	3.0	Tr.	8.0		.0	18	3.0
Approximate average		20	2	50	2	10		.....	170	10
Approximate range:										
Highest		40	.....	60	20	30		.....	200	30
Lowest		4	.....	1	Tr.	1		.....	10	Tr.

[a] Slits in casing admit water from 170-foot stratum; water is therefore a mixture.
[b] $Fe_2O_3 + Al_2O_3$.

TABLE 111.—*Chemical composition of water from the Claiborne group (Eocene)*—Con.

County.	Nitrate radicle (NO_3).	Chlorine (Cl).	Phosphate radicle (PO_4).	Total dissolved solids.	Total hardness as $CaCO_3$.[a]	Free carbon dioxide (CO_2).	Probable scale-forming ingredients.[a]	Probable foaming ingredients.[a]	Probability of corrosion.[a b]	Quality for boiler use.	Mineral content.	Chemical character.	Quality for domestic use.
Richmond	.....	1.2	.....	[c] 20	11	.....	15	5	(?)	Good..	Low .	.....	Good.
Burke	.....	5.2	.....	[d] 147	130	.....	160	5	N.C.	Fair...	...do .	$Ca\text{-}CO_3$.	Do.
Do	.....	7.0	.....	198	163	82	200	15	N.C.	...do ..	Mod..	...do	Do.
Screven	Tr.	3.5	.....	190	118	.....	160	40	N.C.	...do ..	...do .	...do	Do.
Jenkins	.....	8.0	.....	175	115	0	160	20	(?)	...do ..	...do .	...do	Do.
Do	.2	6.0	.....	200	164	.....	200	10	(?)	...do ..	...do .	...do	Do.
Jefferson	4.0	4.0	.....	20	7	.....	10	5	(?)	Good..	Low..	.....	Do.
Do	.....	8.2	3.3	152	88	.....	140	15	(?)	Fair...	Mod..	$Ca\text{-}CO_3$..	Do.
Do	.....	4.7	Tr.	191	155	13	190	30	N.C.	...do ..	...do .	...do	Do.
Washington	.....	5.6	Tr.	213	155	.....	190	50	N.C.	...do ..	...do .	...do	Do.
Do	.....	3.0	.....	166	144	5	180	5	(?)	...do ..	...do .	...do	Do.
Johnson	.2	9.5	.....	226	153	.....	200	15	N.C.	...do ..	...do .	...do	Do.
Do	.....	5.6	.....	[e] 241	164	(*f*)	200	15	(?)	...do ..	...do .	...do	Do.
Ware	.0	12	.....	249	148	.....	170	70	N.C.	...do ..	...do .	...do	Do.
Clay	.3	3.0	.....	174	126	0	150	40	N.C.	...do ..	...do .	...do	Do.
Do	4.0	4.0	.....	80	8	.....	40	20	N.C.	Good..	Low..	$Na\text{-}CO_3$.	Do.
Approximate average	.....	5	.....	190	.....	.....	.....	.....					
Approximate range:													
Highest	.....	10	.....	250	.....	.....	.....	.....					
Lowest	.....	1	.....	20	.....	.....	.....	.....					

[a] Computed.
[b] N. C.=noncorrosive; (?)=uncertain or doubtful.
[c] Volatile matter, 2.1 parts.
[d] Al, 1.6 parts.
[e] Organic and volatile matter, 41 parts.
[f] Present.

JACKSON FORMATION.

The Jackson, the highest formation of the Eocene series, consists mainly of soft limestone and calcareous glauconitic sandy clay. Five analyses of water from wells tapping it in the central part of the State and two of water from a well in Ware County much nearer the coast are recorded in Table 112. Some water from the overlying Vicksburg (Oligocene) probably enters the wells at Dublin. Except the spring water at Americus, which is very low in mineral content, all waters from the Jackson for which analyses are available are hard, moderately high in scale-forming constituents, low in alkalies, and rather poor for boiler use in their natural state, though capable of being rendered thoroughly satisfactory by softening. All are acceptable for domestic use except that from the Bahnsen well, which is high in iron. The limestones and calcareous sands of the Jackson are the evident source of the hardening constituents. The water of the Bahnsen well, except for its content of iron, is similar to that from wells tapping other formations near Americus, and the water from the Jackson at Waycross is similar to that from the Claiborne. Consequently it seems fair to conclude that the water from the Jackson is locally similar to that from other Eocene strata. The figures in Table 112, showing the approximate average mineral content of waters from the Jackson, have been rounded off to avoid appearance of undue accuracy.

TABLE 112.—*Chemical composition of water from the Jackson formation (Eocene).*

[Parts per million except as otherwise designated.]

County.	Location.	Owner or source.	Depth of well.	Depth to principal water-bearing stratum.	Date of collection.
			Feet.	*Feet.*	
Laurens	Dublin	City well [a]		185–295	
Do	Tingle, 7 miles southwest of Dublin.	Jeptha Tingle	242		May 11, 1911
Dooly	Unadilla	Town well	189	189	June 5, 1911
Sumter	Americus, 1½ miles south of	P. F. Bahnsen	180	177–180	Dec. 16, 1912
Do	Americus	City springs			Apr. 19, 1911
Ware	Waycross	Town wells (2)	700	670–700	Apr. 8, 1911
Do	do	do	700	670–700	
Brooks	Quitman	Town well	699	650–699	

County.	Analyst.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).
Laurens	Edgar Everhart	20	[b] 2.6	68	3.7	6.6	3.1	0.0	211	17
Do	do	32	1.5	58	3.0	8.0		.0	203	1.0
Dooly	do	16	1.0	45	1.0	5.0		.0	158	7.0
Sumter	do	34	10	32	9.0	16		.0	176	13
Do	do	17	.6	2.0	1.0	5.0		.0	17	Tr.
Ware	do	45	.2	40	18	24		.0	175	49
Do	H. C. White	9.9	1.0	54	.6	2.8	.5	78	.....	10
Brooks	do	17	.2	39	9.4	4.9	3.7	.....	154	3.8
Approximate average		25	3	40	5	10		.....	150	10

County.	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Total hardness as $CaCO_3$. [c]	Probable scale-forming ingredients. [c]	Probable foaming ingredients. [c]	Probability of corrosion. [c d]	Quality for boiler use.	Mineral content.	Chemical character.	Quality for domestic use.
Laurens	.....	5.6	[e] 231	185	230	25	(?)	Poor..	Mod ..	$Ca\text{-}CO_3$..	Good.
Do	Tr.	5.0	256	157	210	20	N. C.	...do ..	...do ..	...do.....	Do.
Dooly	0.2	3.5	134	117	150	15	N. C.	Fair...	Low ..	...do.....	Do.
Sumter	.0	4.0	209	117	143	40	N. C.	...do ..	Mod ..	...do.....	Poor.
Do	Tr.	3.0	50	9	25	15	N. C.	Good..	Low ..	$Na\text{-}CO_3$.	Good.
Ware	.0	20	296	174	190	60	(?)	Fair...	Mod ..	$Ca\text{-}CO_3$..	Do.
Do	.....	3.6	[f] 177	137	170	16	(?)	...do ..	...do ..	...do.....	Do.
Brooks	.....	4.6	159	136	150	25	(?)	...do ..	...do ..	...do.....	Do.
Approximate average	.....	5	200	.....	.....	.....	.....	.....	.....	.....	

[a] One of the wells of the municipal water supply, which range from 300 to 850 feet in depth.
[b] $Fe_2O_3+Al_2O_3$.
[c] Computed.
[d] N. C.=noncorrosive; (?)=uncertain or doubtful.
[e] Free CO_2 64 parts.
[f] Organic and volatile matter 16 parts.

MISCELLANEOUS STRATA.

The strata of Eocene age include the Midway, Wilcox, McBean, Barnwell, and Jackson formations, whose waters, except those from the Wilcox, are considered under separate headings. The Wilcox,

which overlies the Midway formation, includes lignitic and glauconitic clay somewhat like fuller's earth and unconsolidated sand and clay, but little is known in regard to the quality of its waters.

Besides the analyses reported under the headings above mentioned, sixteen analyses of waters from Eocene strata that could not be definitely identified are available, and these are grouped in Table 113. The well at Byromville yields water essentially like that from the well at Unadilla in the same county, which taps the Jackson formation. The well at Pembroke is reported to receive water from three horizons, and its chief source can not be identified. The wells at Statesboro and at Adel present the recorded extremes of mineral content; as both, according to Stephenson, are probably from the upper part of the Eocene they may be noted as examples of the wide range of mineralization that waters from a given formation may acquire from local differences in composition of the water-bearing beds, in quantity of seepage from other formations, and in other conditions. Two waters reported to be from the Eocene at Leesburg differ markedly in composition, that from the shallower well being somewhat lower in mineral content but nearly twice as hard as that from the deeper well.

TABLE 113.—*Chemical composition of water from undifferentiated Eocene strata*

[Parts per million except as otherwise designated.]

County.	Location.	Owner or source.	Depth of well.	Depth to principal water-bearing stratum.	Date of collection.
			Feet.	*Feet.*	
Baker	Newton	Public well	825	.....	
Ben Hill	Fitzgerald	Town well	825	.....	
Berrien	Adel	....do	675	.....	June 13, 1911
Bryan	Pembroke	U. S. Williams	520	520	Dec. 17, 1912
Bulloch	Statesboro	W. D. Davis	320	.....	
Decatur	Bainbridge	Town well	900	280, 370	
Do	....do	....do	1,250	370	
Dooly	Byromville	....do	1,100	320	May 30, 1911
Grady	Cairo	Public well	750	750	May 13, 1911
Lee	Armena	I. P. Cocke	290	290	
Do	Leesburg	Public well	540	.....	
Do	....do	City light plant	300	.....	Mar., 1909
Montgomery	Lumber City, 5 miles northeast of.	McArthur	900	890–900	Apr. 17, 1911
Toombs	Lyons	Town well	406	400–406	Apr. 15, 1911
Wayne	Jesup	....do	675	600–670	Dec. 14, 1912
Do	Mount Pleasant	L. R. Akin	730	.....	Dec. 23, 1912

TABLE 113.—*Chemical composition of water from undifferentiated Eocene strata*—Con.

County.	Analyst.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).
Baker	Edgar Everhart	20	[a] 3.6	.....	4.5	3.2	59	1.9	0.0	162	9.3
Ben Hill	do	13	[a] 10	.....	20	5.2	8.2	1.9	.0	72	3.7
Berrien	do	47	4.0	.....	150	72	22		.0	168	518
Bryan	do	34	2.0	.....	22	8.0	22		.0	140	8.0
Bulloch	do	43	[a] 5.0	.....	1.5	.8	2.9	2.7	.0	3.4	3.4
Decatur	H. C. White	3.9	9.8	.....	62	4.6	26		85	.....	58
Do	do	4.0	.1	.....	29	.1	57		82	.....	32
Dooly	Edgar Everhart	22	.2	.....	24	12	8.0		.0	88	20
Grady	do	24	.4	.....	54	12	28		.0	173	112
Lee	do	9.2	[a] 2.1	.....	60	.7	1.9	.7	.....	183	5.9
Do	do	35	[a] 6.2	.....	26	3.4	27	5.0	.....	151	13
Do	do	18	.5	0.5	54	1.2	2.9	.3	.....	148	3.1
Montgomery	do	17	1.4	.....	16	4.0	32		1.0	159	2.0
Toombs	do	9.0	.6	.....	9.0	1.0	36		.0	118	6.0
Wayne	do	40	6.0	.....	19	20	26		.0	177	35
Do	do	42	4.0	.....	31	24	25		.0	177	70

County.	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Total hardness as $CaCO_3$.[b]	Free carbon dioxide.	Probable scale-forming ingredients.[b]	Probable foaming ingredients.[b]	Probability of corrosion.[b c]	Quality for boiler use.	Mineral content.	Chemical character.	Quality for domestic use.
Baker	.....	7.0	190	24	74	40	160	N. C.	Fair...	Mod..	$Na-CO_3$.	Good.
Ben Hill	.....	20	[d] 118	71	28	80	25	(?)	Good..	Low..	$Ca-CO_3$.	Fair.
Berrien	0.0	21	972	670	.....	610	60	C.	Bad...	High..	$Ca-SO_4$..	Poor.
Bryan	3.0	10	171	88	.....	110	60	N. C.	Fair...	Mod..	$Ca-CO_3$..	Good.
Bulloch	.....	6.8	69	7	3.0	50	15	C.	Poor..	Low..	Na-Cl...	Fair.
Decatur	.....	21	293	174	.....	190	70	(?)	Fair...	Mod..	$Ca-CO_3$..	Do.
Do	.....	17	[e] 221	73	.....	90	150	N. C.	...do..	...do...	$Na-CO_3$.	Good.
Dooly	.1	15	137	109	.....	110	20	(?)	...do..	...do...	$Ca-CO_3$.	Do.
Grady	.2	19	342	184	.....	200	80	(?)	...do...	...do..	$Ca-SO_4$..	Do.
Lee	.....	6.3	174	153	22	190	5	(?)	...do..	...do...	$Ca-CO_3$.	Do.
Do	.....	5.2	195	79	.....	120	90	N. C.	...do...	...do...	$Na-CO_3$.	Fair.
Do	.....	3.0	169	140	.....	180	10	(?)	...do..	...do...	$Ca-CO_3$..	Good.
Montgomery	.1	9.0	183	56	.....	70	90	N. C.	Good..	...do..	$Na-CO_3$.	Do.
Toombs	.1	11	112	27	.....	40	100	N. C.	...do..	Low..	...do.....	Do.
Wayne	Tr..	7.0	229	129	.....	130	70	N. C.	Fair...	Mod..	$Ca-CO_3$..	Fair.
Do	Tr..	18	303	176	.....	170	70	(?)	...do..	...do...	...do....	Do.

[a] $Fe_2O_3+Al_2O_3$.
[b] Computed.
[c] C=corrosive; N. C.=noncorrosive; (?)=uncertain or doubtful.
[d] PO_4 trace.
[e] Organic and volatile matter 1.0 part.

OLIGOCENE SERIES.

VICKSBURG FORMATION.

The Vicksburg formation is chiefly soft heavy-bedded limestone overlain by beds of sand and clay. The limestone has been extensively dissolved by percolating waters charged with carbon dioxide, and therefore much of its water circulates in open channels and caverns instead of slowly filtering, as in sand. Consequently the chances of pollution of these sources through sink holes and other underground passages are worth attention, for polluted water can be carried long distances

in a very short time through limestone channels without being purified any more than if it were passing through an iron pipe. The opportunities of such contamination are of course greatest where the formation is exposed and least where it is deeply buried. To determine whether or not the circulating waters at any given place are polluted chemical analyses are practically useless, but much may be learned by bacteriologic examinations and by using fluorescein or other dyes to trace the underground courses.

The wells tapping the Vicksburg are scattered over the southeast half of the Coastal Plain, some being almost on the seacoast. Analyses of water from 28 of them, given in Table 114, show more plainly than the analyses heretofore considered the effect of contact with calcareous material. None of them contains less than 100 parts per million of total solids, and all but 6 exceed 100 parts in hardness. Springs from earlier formations yield waters very low in mineral content, but springs from the Vicksburg yield hard waters comparable in most respects to those from wells. Lovett Spring, issuing from the cavernous limestone of the Vicksburg, yields water much more strongly mineralized than that from two other springs in Laurens County; and the springs at Coney and Albany yield similarly hard waters. The well waters range generally in dissolved solids from 100 to 300 parts per million and in hardness from 70 to 200 parts. One unusually strong water, from the town well at St. Marys, contains 504 parts per million of total solids. The close similarity of the waters from three different horizons in the old town well at Valdosta furnishes no basis for the belief that mineral content increases with depth of source. On the other hand, the great difference in content of iron between the two waters from Mr. Brown's wells near Philema attests the effect of local differences in the formation.

The supplies from the Vicksburg are distinctly calcium carbonate waters of moderate mineral content. They are generally hard but not too hard for domestic use, and they are acceptable if they do not also contain enough iron to taste unpleasant. They carry enough scale-forming matter to make softening advisable before they are used for boiler feed, but they are not likely to foam or cause corrosion. They may be classed as fair or poor for boilers in their natural state, but they can be rendered entirely satisfactory by preliminary treatment. The high sulphate content of some of the waters renders them less desirable for industrial use, for waters high in sulphate deposit a harder scale in boilers than those proportionately higher in carbonates. All the waters are low in chloride. The figures at the bottom of the table, which represent numerically the average chemical composition of the waters from the Vicksburg, have been rounded off to indicate approximate conditions and should not be too literally interpreted.

TABLE 114.—*Chemical composition of water from the Vicksburg formation (Oligocene).*

[Parts per million except as otherwise designated.]

County.	Location.	Owner or source.	Depth of well.	Depth to principal water-bearing stratum.	Date of collection.
			Feet.	*Feet.*	
Johnson	Idylwild, 3 miles south of Wrightsville.		305	100	
Laurens	Lovett	L. P. Fordham	Spring.		July, 1909
Dodge	Chester	Carson Naval Stores Co.	158	158	Mar., 1910
Jeff Davis	Hazelhurst	Public well	643	482–643	Apr. 6, 1911
Dooly	Vienna, 5 miles northwest of.	J. T. McNeese	137.5	136–137.5	July 10, 1911
Crisp	Cordele	Public well	396	375	
Do	Coney, 2 miles west of.	Spring of Georgia Land Corporation.			June 10, 1911
Turner	Ashburn	Public well	500	500	June 15, 1911
Irwin	Ocilla	do	355		Apr. 4, 1911
Lee	Philema Quarters	S. B. Brown	142		Mar. 30, 1911
Do	Starr farm near Philema.	do	114		Do.
Tift	Tifton	Town well	550	300–550	May 24, 1911
Do	do	H. H. Tift	368	330–368	
Do	do	Tifton Ice & Power Co.	572.5	340–512	
Dougherty	Albany, 4 miles south of	Blue Spring		20–30	Apr. 1, 1911
Berrien	Sparks	Town well	407		
Lowndes	Valdosta	Public well	500	360–500	
Do	do	Old town well	522	360	
Do	do	do	522	460	
Do	do	do	522	515	
Thomas	Boston	Town well	320	130–320	
Do	Thomasville	Town well No. 1			
Do	do	Town well No. 2			
Mitchell	Camilla	City well	207	100–207	June 7, 1911
Miller	Colquitt	Town well	246.5	140	Dec. 23, 1912
Chatham	Savannah	City wells	(a)	(a)	Apr. 11, 1911
Do	do	Former public supply		500±	1886
Camden	St. Marys	Town well	522	500–522	May 6, 1911

County.	Analyst.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).
Johnson	J. M. McCandless	35	[b] 1.0	....	35	0.8	2.2		.....	87	0.6
Laurens	Edgar Everhart	17	.1	....	50	.2	5.0	0.4	.....	144	2.6
Dodge	do	28	1.4	....	35	1.4	2.4	.5	.....	112	1.3
Jeff Davis	do	24	.4	....	52	4.0	18		2.5	178	9.0
Dooly	do	20	Tr.	....	48	8.0	6.0		.0	170	3.0
Crisp	do	11	[b] 2.9	....	44	1.1	4.6		.0	134	4.4
Do	do	34	.4	....	56	.4	6.0		Tr.	159	9.0
Turner	do	26	.4	....	24	7.0	8.0		2.0	117	8.0
Irwin	do	18	1.5	....	34	6.2	5.6		.0	158	Tr.
Lee	do	13	12	....	49	2.0	4.0		.0	178	2.0
Do	do	12	1.5	....	44	3.2	2.9		.0	166	4.8
Tift	do	28	.2	....	44	2.0	18		.0	181	6.0
Do	H. C. White	16	.1	5.3	73	.8	8.3	4.1	116	.....	12
Do	Boiler Compound Co.	16	[b] 3.8	....	35	4.9	8		34	.....	49
Dougherty	Edgar Everhart	12	.4	....	49	2.4	3.8		.0	178	2.0
Berrien	do	31	.3	....	50	16	4.3	.6	.....	136	72
Lowndes	do	15	[b] 6.1	....	25	3.1	2.8	1.1	.0	61	24
Do	H. C. White	6.7	1.2	.6	42	.6	3.5	.4	56	.....	13
Do	do	8.0	1.1	.5	35	.7	3.1	.5	48	.....	12
Do	do	12	1.4	.9	41	.7	2.3	.3	56	.....	14
Thomas	Edgar Everhart	20	[b] 18	....	40	4.0	5.4	2.0	.0	128	8.8
Do	do	20	[b] 1.6	....	48	22	9.0	2.6	.0	179	81
Do	do	20	[b] 1.4	....	48	22	7.8	2.1	.0	159	82
Mitchell	do	23	.8	....	46	1.0	3.0		.0	150	5.0
Miller	do	6.0	.5	....	40	2.5	6.0		.0	148	Tr.
Chatham	do	58	1.0	....	26	10	17		2.0	170	8.0
Do	C. F. Chandler	55	[b] .4	....	25	7.2	10	1.7	.....	.....	11
Camden	Edgar Everhart	43	.4	....	73	8.0	60		.0	152	170
Approximate average		20	1	....	40	5	10		0	140	20
Approximate range:											
Highest		60	10	....	70	20	20		.....	200	80
Lowest		10	Tr.	....	25	1	2		.....	60	Tr.

[a] Twelve wells 475–500+ feet deep and one well 1,550 feet deep. The 1,550-foot well probably enters the Cretaceous, but the others draw from the Vicksburg.

[b] $Fe_2O_3+Al_2O_3$.

TABLE 114.—*Chemical composition of water from the Vicksburg formation (Oligocene)*—Continued.

County.	Nitrate radicle (NO_3).	Chlorine (Cl).	Phosphate radicle (PO_4).	Organic and volatile matter.	Total dissolved solids.	Total hardness as $CaCO_3$.[a]	Free carbon dioxide (CO_2).	Probable scale-forming ingredients.[a]	Probable foaming ingredients.[a b]	Probability of corrosion.[a]	Quality for boiler use.	Mineral content.	Chemical character.	Quality for domestic use.
Johnson	....	3.0	0.1	....	.....	91	....	140	5	(?)	Fair...	Low..	$Ca-CO_3$.	Good.
Laurens	....	5.0	....	....	158	126	....	170	15	(?)	...do...	Mod..	...do....	Do.
Dodge	....	4.2	....	....	132	93	....	130	10	(?)	...do...	Low..	...do....	Do.
Jeff Davis	Tr.	9.5	....	....	231	146	....	180	50	N. C.	...do...	Mod...	...do....	Do.
Dooly	0.1	5.0	....	....	181	153	....	170	15	(?)	...do...	...do...	...do....	Do.
Crisp	....	5.6	....	....	141	114	2	140	10	(?)	...do...	Low..	...do....	Do.
Do	.2	4.5	....	....	196	142	....	200	15	(?)	...do...	Mod...	...do....	Do.
Turner	.2	3.5	....	....	100	89	....	100	20	N. C.	...do...	Low..	...do....	Do.
Irwin	Tr.	4.5	....	....	144	110	....	130	15	N. C.	...do...	...do...	...do....	Do.
Lee	.2	3.6	.1	....	177	131	....	160	10	N. C.	...do...	Mod..	...do....	Poor.
Do	2.5	3.0	....	....	167	123	....	150	10	N. C.	...do...	...do...	...do....	Good.
Tift	.1	5.0	....	....	192	118	....	160	50	N. C.	...do...	...do...	...do....	Do.
Do	....	.7	....	7.0	250	186	....	230	30	N. C.	Poor..	...do...	...do....	Do.
Do	....	12	....	....	176	108	....	120	20	(?)	Fair...	...do...	$Ca-SO_4$.	Do.
Dougherty	1.5	3.5	....	....	139	132	....	160	10	N. C.	...do...	Low..	$Ca-CO_3$.	Do.
Berrien	....	5.0	....	....	252	191	....	210	15	(?)	Poor..	Mod..	$Ca-SO_4$.	Do.
Lowndes	....	5.4	....	....	113	75	27	90	10	(?)	Good..	Low..	$Ca-CO_3$.	Fair.
Do	....	4.9	....	20	150	107	....	130	10	(?)	Fair...	...do...	...do....	Good.
Do	....	4.2	....	23	138	90	....	110	10	(?)	...do...	...do...	...do....	Do.
Do	....	2.9	....	16	149	105	....	130	5	(?)	...do...	...do...	...do....	Do.
Thomas	....	9.5	.4	....	174	116	18	140	20	(?)	...do...	Mod..	...do....	Poor.
Do	....	12	Tr.	....	278	210	4	200	30	(?)	...do...	...do...	...do....	Fair.
Do	....	12	Tr.	....	274	210	20	200	30	(?)	...do...	...do...	...do....	Do.
Mitchell	.4	2.0	....	....	137	119	....	160	10	N. C.	...do...	Low..	...do....	Good.
Miller	.5	3.5	....	....	129	110	....	130	15	N. C.	...do...	...do...	...do....	Do.
Chatham	.4	7.0	....	....	220	106	....	150	50	N. C.	...do...	Mod..	...do....	Do.
Do	2.2	11	Tr.	9.0	229	92	....	140	30	.....	...do...	...do...	...do....	Do.
Camden	Tr.	33	....	....	504	215	....	270	160	(?)	Poor..	High..	$Ca-SO_4$.	Fair.
Approximate average	....	5	....	....	190	.....	....	.....	....	.....	.....	.....	.....	
Approximate range:														
Highest	....	12	....	....	300	.....	....	.....	....	.....	.....	.....	.....	
Lowest	....	.5	....	....	100	.....	....	.....	....	.....	.....	.....	.....	

[a] Computed. [b] N. C.=noncorrosive; (?)=uncertain or doubtful.

CHATTAHOOCHEE FORMATION.

The Chattahoochee formation, like the Vicksburg, which underlies it in many places, is mostly limestone, and its waters are similar to those of the Vicksburg. Only a few analyses of waters from the Chattahoochee in the southern part of the State are available (see Table 115), but these represent calcium carbonate waters of moderate mineral content generally good for domestic use except for their hardness and generally fair for boiler use. Most of the waters contain enough scale-forming matter to deposit considerable scale, but it would be soft and most of it could readily be blown from boilers as sludge, though it would be better to soften the supplies before use. From the limited information concerning the composition of the waters from the Chattahoochee it may be concluded that they range in mineral content from 150 to 300 parts and in hardness from 100 to 200 parts per million. One water analyzed contains 92 parts per million of sulphate and one contains 35 parts of chlorine, but most waters from the formation probably contain

less than 10 parts of either radicle. The waters from the Chattahoochee in Worth County are much alike, but they differ from one another as much as they do from the waters of the Eocene or Cretaceous.

TABLE 115.—*Chemical composition of water from the Chattahoochee formation (Oligocene).*

[Parts per million except as otherwise designated.]

County.	Location.	Owner or source.	Depth of well.	Depth to principal water-bearing stratum.	Date of collection.
			Feet.	*Feet.*	
Camden	Tarboro	Stafford Bros	400	350–375	Apr. 14, 1911
Wilcox	Abbeville, 1 mile north of.	Poor Robin Spring	.....	.....	June 1, 1911
Worth	Sylvester	Town well	200±	.....	Aug., 1908
Do	do	Joseph McGrill (?)	100	.....	Do.
Brooks	Quitman	Town well	321	310	
Echols	Statenville	Garbett Lumber Co	148	71–148	June 7, 1911

County.	Analyst.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).
Camden	Edgar Everhart	36	0.4	45	26	17		0.0	178	92
Wilcox	do	14	.4	54	4.0	3.0		.0	185	1.0
Worth	do	21	.1	51	7.3	12	2.5	.....	198	.7
Do	do	26	.4	54	7.2	24	7.0	.0	209	2.0
Brooks	do	28	13	23	9.1	4.1	.7	.0	120	Tr.
Echols	do	34	.2	25	11	12		.0	136	12
Approximate average		25	.....	40	10	15		.....	170	.....

County.	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Total hardness as $CaCO_3$.[a]	Probable scale-forming ingredients.[a]	Probable foaming ingredients.[a]	Probability of corrosion.[a b]	Quality for boiler use.	Mineral content.	Chemical character.	Quality for domestic use.
Camden	1.5	14	323	219	210	50	(?)	Poor	Mod.	$Ca–SO_4$	Good.
Wilcox	.2	3.5	190	151	180	10	(?)	Fair	do	$Ca–CO_3$	Do.
Worth	.....	7.0	[c] 204	157	180	40	N. C.	do	do	do	Do.
Do	.0	35	[d] 261	164	200	80	N. C.	do	do	do	Do.
Brooks	.....	5.8	[e] 153	95	110	15	N. C.	do	do	do	Poor.
Echols	Tr.	12	182	108	130	30	N. C.	do	do	do	Good.
Approximate average	.....	8	200	.....	.....	.....	.....	.....	.....	.....	

[a] Computed.
[b] N. C.=noncorrosive; (?)=uncertain or doubtful.
[c] Al 0.2 part.
[d] Al 0.5; PO_4 1.6; free CO_2 4 parts per million.
[e] Al 2.6; free CO_2 90 parts.

ALUM BLUFF FORMATION.

The Alum Bluff formation consists chiefly of sand, clay, and gravelly beds of coarse sandstone or grit with local beds of clay, and it includes marine deposits of clayey sand and sandy laminated clay. Though the formation is widely distributed, very few waters from it

have been analyzed. (See Table 116.) The mineral content and hardness of these indicate that the strata contain some calcareous material. The extremely low mineral content of the spring water at Kibbee indicates that the supply comes from a sandy or gravelly bed in which circulation is rapid.

TABLE 116.—*Chemical composition of water from the Alum Bluff formation (Oligocene).*

[Parts per million except as otherwise designated.]

County.	Location.	Owner or source.	Depth of well.	Depth to principal water-bearing stratum.	Date of collection.
			Feet.	*Feet.*	
Tattnall	Reidsville	Town well	275	.....	Feb. 14, 1913
Montgomery	Kibbee	Mrs. N. H. Mason	Spring.	.....	Oct., 1909
Telfair	Shamrock Springs	.....	140	.....	Nov., 1907
Appling	Baxley	Town well	[a] 204	200	
Crisp	Cordele, 1 mile east of	J. W. Cannon	155	67	May 20, 1911

County.	Analyst.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).
Tattnall	Edgar Everhart	72	5.0	.....	13	7.0	12		0.0	86	11
Montgomery	do	12	.5	0.2	1.6	.6	1.5	0.8	.....	33	1.4
Telfair	do	43	.1	.1	62	9.8	7.1	1.7	.....	221	4.7
Appling	do	97	[b]17	.....	3.9	.7	13	4.4	.0	27	1.6
Crisp	do	9.0	.2	.....	44	Tr.	11		.0	150	8.0

County.	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Total hardness as $CaCO_3$. [c]	Probable scale-forming ingredients. [c]	Probable foaming ingredients. [c]	Probability of corrosion. [c] [d]	Quality for boiler use.	Mineral content.	Chemical character.	Quality for domestic use.
Tattnall	Tr.	4.0	165	61	120	30	N. C.	Fair...	Mod...	$Ca–CO_3$.	Fair.
Montgomery	.....	4.0	27	6	20	5	N. C.	Good..	Low..	$Na–CO_3$.	Good.
Telfair	.....	10	251	195	240	25	(?)	Poor..	Mod...	$Ca–CO_3$.	Do.
Appling	.....	12	[e] 169	13	110	50	N. C.	Fair...	...do...	$Na–CO_3$.	Poor.
Crisp	1.0	3.5	172	110	140	30	N. C.	...do...	...do...	$Ca–CO_3$.	Good.

[a] Originally 461 feet deep; now partly filled with sand.
[b] $Fe_2O_3+Al_2O_3$.
[c] Computed.
[d] N. C.=noncorrosive; (?)=uncertain or doubtful.
[e] PO_4 5.4 parts; free CO_2 31 parts.

MISCELLANEOUS STRATA.

Eight analyses of water from strata of Oligocene age, comprising the Vicksburg, Chattahoochee, and Alum Bluff formations, are grouped in Table 117, either because the exact horizon from which the supplies come could not be determined or because the wells draw from several horizons. The well at Dover taps two water-bearing beds, at 125 and 225 feet, which are either in the Chattahoochee or in

the Vicksburg. The wells at Helena penetrate sand, clay, and thin layers of hard rock. The wells at Douglas, Willacoochee, and Lumber City receive their supplies either from the Chattahoochee or the Vicksburg.

TABLE 117.—*Chemical composition of water from undifferentiated Oligocene strata.*

[Parts per million except as otherwise designated.]

County.	Location.	Owner or source.	Depth of well.	Depth to principal water-bearing stratum.	Date of collection.
			Feet.	*Feet.*	
Bulloch	Register, 3½ miles southwest of.	J. W. Atwood	Spring.		Dec., 1909
Coffee	Douglas	Town well	409	325,390	
Do	Willacoochee	do	408	350	Apr. 5, 1911
Screven	Dover	Central of Georgia Ry	350	125,225	
Telfair	Helena	McRae Coca Cola Bottling Co.	250	250	Apr. 18, 1911
Do	do	Helena Ice Co		220	
Do	Scotland	A. Graham	160		Apr. 17, 1911
Do	Lumber City	Town well	430	320–425	

County.	Analyst.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na_2).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).
Bulloch	Edgar Everhart	4.8	3.5	1.1	0.6	4.5	0.3	.....	74	0.9
Coffee	do	83	a34	34	7.2	12	4.6	0.0	158	2.6
Do	do	36	1	37	11	6.0		.0	160	27
Screven	do	50	a4.2	36	6.2	20	7.1	.....	149	3.9
Telfair	do	44	2.0	43	8.0	18		2.5	207	2.0
Do	Dearborn Chemical Co	30	a1.3	46	8.0	11		78	.....	14
Do	Edgar Everhart	38	.4	54	6.0	12		Tr.	246	2.0
Do	do	8.3	a17	40	5.1	8.1	2.6	58	.....	30

County.	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Total hardness as $CaCO_3$.[b]	Probable scale-forming ingredients.[b]	Probable foaming ingredients.[b]	Probability of corrosion.[b c]	Quality for boiler use.	Mineral content.	Chemical character.	Quality for domestic use.
Bulloch	.....	6.3	d29	5	10	15	N. C.	Good	Low	$Na-CO_3$	Fair.
Coffee	.....	10	e266	114	200	40	N. C.	Fair	Mod	$Ca-CO_3$	Bad.
Do	0.2	5.0	210	138	160	15	(?)	do	do	do	Good.
Screven	.....	29	229	115	170	70	N. C.	do	do	do	Fair.
Telfair	Tr.	10	262	140	180	50	N. C.	do	do	do	Good.
Do	.....	18	f210	148	180	30	(?)	do	do	do	Do.
Do	.5	8.0	272	160	210	30	N. C.	Poor	do	do	Do.
Do	.....	10	180	121	130	30	N. C.	Fair	do	do	Poor.

a $Fe_2O_3+Al_2O_3$.
b Computed.
c N. C.=noncorrosive; (?)=uncertain or doubtful.
d Al 0.2 part.
e Free CO_2 42 parts.
f Organic and volatile matter 4.0 parts.

UNDIFFERENTIATED OLIGOCENE TO PLEISTOCENE, INCLUSIVE.

Analyses of waters from certain deposits, to which no specific name has been given but which have been grouped as "undifferentiated Oligocene to Pleistocene, inclusive," are given in Table 118. The

nature of these deposits is discussed on page 94, and many shallow wells in central Georgia enter them. The few available analyses indicate that water from these beds is generally good for boiler and domestic uses, being usually low in mineral content and relatively soft.

TABLE 118.—*Analyses of water from "undifferentiated Oligocene to Pleistocene, inclusive."*

[Parts per million.]

County.	Location.	Owner.	Depth of well.	Date of collection.	Analyst.
Screven	Eureka Spring, 12 miles south of Sylvania.	H. S. White	Spring	July, 1909	Edgar Everhart.
Jenkins	Thrift, 1 mile east of.	Jones's spring			Do.
Emanuel	Magnolia Spring, 4 miles southeast of Stillmore.				Do.
Liberty	Donald, 10 miles northwest of Ludowici.	T. J. Harrington.	Spring		Do.
Laurens	Lovett, ¼ mile southwest of.	O. W. Parker	do	Sept., 1909	Do.
Montgomery	Higgston, near	W. A. Calhoun	do		Do.
Coffee	Douglas, 2 miles east of.	Gaskins Spring		Apr. 5, 1911	Do.
Tift	Tifton, 4 miles west of.	Murrow Mineral Spring Co.		Apr. 3, 1911	Do.
Clinch	Argyle, near		Spring	Aug., 1909	Do.
Toombs	Normantown	J. M. and C. S. Meadows.	do		

County.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).
Screven	5.2	6.3	0.1	1.4	0.2	3.4	0.4	.....	61	1.4	.....
Jenkins	6.0	.8	.....	2.5	.6	5.9	.4	.....	28	1.8	.....
Emanuel	5.0	1.0	.....	.2	.3	1.6	.8	.....	4.2	.4	.....
Liberty	8.5	3.5	.2	2.0	1.6	4.7	.4	.....	114	.9	.....
Laurens	14	.2	.....	1.5	.8	2.8	.1	.....	10	2.4	.....
Montgomery	10	30	Tr.	.7	.1	1.9	Tr.	.....	36	Tr.	.....
Coffee	12	Tr.	.....	2.0	1.0	6.0		0.0	11	Tr.	1.0
Tift	22	.2	.....	38	2.0	6.0		.0	154	Tr.	Tr.
Clinch	7.7	9.1	2.6	.8	.5	4.9		.....	144	1.4	.....
Toombs	2.4	.5	.1	1.8	.7	3.2	.3	.....	28	1.4	.....

County.	Chlorine (Cl).	Total dissolved solids.	Total hardness as $CaCO_3$.[a]	Probable scale-forming ingredients.[a]	Probable foaming ingredients.[a]	Probability of corrosion.[a b]	Quality for boiler use.	Mineral content.	Chemical character.	Quality for domestic use.
Screven	5.0	33	4.3	10	10	N. C.	Good	Low	$Na\text{-}CO_3$	Fair.
Jenkins	8.9	34	8.7	16	17	N. C.	do	do	do	Good.
Emanuel	4.0	15	1.7	7	5.7	N. C.	do	do	Na-Cl	Do.
Liberty	8.7	41	12	21	14	N. C.	do	do	$Na\text{-}CO_3$	Do.
Laurens	4.4	30	7	22	7.8	N. C.	do	do	do	Do.
Montgomery	2.8	86	2.2	12	5.1	N. C.	do	do	do	Bad.
Coffee	5.0	36	9.1	22	16	(?)	do	do	do	Good.
Tift	3.0	168	103	142	16	N. C.	Fair	Mod	$Ca\text{-}CO_3$	Do.
Clinch	10	69	4.0	12	13	N. C.	Good	Low	$Na\text{-}CO_3$	Poor.
Toombs	5.2	20	.....	11	9.4	N. C.	do	do	do	Good.

[a] Computed.

[b] NC.=noncorrosive; (?) uncertain or doubtful.

SUMMARY.

The averages computed from Tables 107 to 116, inclusive, and collected in Table 119 show some striking general similarities and differences in the waters from the various formations of the Coastal Plain. The Chattahoochee and the Vicksburg, both of which include massive beds of limestone, yield waters of practically the same composition; the composition of individual waters from either formation has far greater range than the general differences between the averages. The rather meager information regarding waters from the Alum Bluff indicates that they are somewhat softer than those from other formations of the Oligocene. The three averages portraying the quality of waters from Eocene formations show that the supplies from that series are generally similar in composition to those from Oligocene strata. The waters from the Jackson formation and the formations of the Claiborne group have wider range of mineral content than those from the Chattahoochee and the Vicksburg formations, but the averages show that the waters from all four formations have practically the same general characteristics. Apparently the differences in composition that may be found from place to place in waters from a given formation, and those that may be found in waters from various horizons of Eocene and Oligocene formations at a given place, are much greater than the general differences between supplies from the various water-bearing beds. Evidently, then, no particular formation of these two series yields markedly superior or inferior water, and choice of the proper horizon to tap for domestic or industrial supplies must depend on local conditions. The formations of the Oligocene and Eocene series furnish rather hard calcium carbonate waters of moderate mineral content, practically all of which are acceptable for domestic use. Most of them should be softened before being used in boilers, as they carry appreciable quantities of scale-forming matter.

TABLE 119.—*Approximate chemical composition of waters from the chief water-bearing strata.*

[Parts per million.]

Source.	Number of analyses.	Silica. (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total dissolved solids.
Chattahoochee..	7	25	.....	40	10	15	170	.....	8	200
Vicksburg.....	28	20	1	40	5	10	140	20	5	190
Oligocene [a].....	46	25	4	40	5	10	140	20	8	190
Jackson.....	7	25	3	40	5	10	150	10	5	200
Claiborne.....	16	20	2	50	2	10	170	10	5	190
Eocene [b].....	46	20	3	40	5	15	170	15	8	200
Ripley.....	25	20	3	20	3	20	120	10	8	150
Arkosic sands...	7	20	.....	10	2	10	45	5	5	75

[a] Includes undifferentiated strata of the Alum Bluff, Chattahoochee, and Vicksburg formations.
[b] Includes undifferentiated strata of the Jackson, Midway, and Wilcox formations and the Claiborne group.

Though the waters from the Ripley, like those from later formations, differ much from one another in composition, they are as a class noticeably lower in mineral content and softer than waters from Tertiary rocks. The average total solids in supplies from the Ripley is 50 parts per million less than that in supplies from the Vicksburg; the content of calcium is half as great; and there is almost a corresponding difference in bicarbonates. For industrial uses, therefore, waters from the sand beds of the Ripley are generally better than those from later formations. Waters from typical marine beds of the Ripley are possibly more strongly mineralized.

The waters from the arkosic sands of the Lower Cretaceous are lowest of all in mineral content, as may be expected from the fact that these beds contain relatively little calcareous material.

The presence of hydrogen sulphide gas and excessive amounts of iron has been reported in waters from all formations of the Coastal Plain. The gas imparts an objectionable odor to some of the waters and may cause corrosion of boilers and water mains. Iron when present in amounts exceeding 2 or 3 parts per million is likely to be perceptible to the taste and to cause stains on fabrics washed in the water.

The waters in the limestones and other calcareous deposits of the Coastal Plain of Georgia are much alike in composition, but they differ materially from the waters in the older, harder, and more compact limestones of other parts of the United States. This is clearly shown in Table 120, in which the average composition of supplies from the Vicksburg is compared with that of supplies from the "Niagara" limestone of southwestern Ohio [1] and with that from limestones yielding fresh water in north-central Indiana.[2] The Ordovician, Silurian, and Devonian limestones from which fresh water is obtained in Indiana are compact, massive, and generally fine grained and dolomitic in many places. The "Niagara" of southwestern Ohio is a massive granular to compact Silurian limestone containing a rather large percentage of magnesium. The Vicksburg formation is softer, coarser, and much lower in magnesian content. These differences are reflected in the composition of the waters from these beds; waters from the Vicksburg contain only about one-eighth as much magnesium as calcium, whereas waters from the older limestones of the Central States contain one-third to one-half as much magnesium as calcium. The waters from the Vicksburg are much lower in total mineral content and in all constituents except silica, which though exhibiting local differences seems to be relatively constant, irrespective of the range of other

[1] Dole, R. B., Chemical character of the waters of southwestern Ohio: U. S. Geol. Survey Water-Supply Paper 259, p. 212, 1912.

[2] Dole, R. B., Chemical character of the waters of north-central Indiana: U. S. Geol. Survey Water-Supply Paper 254, p. 261, 1910.

constituents. The relatively small content of sulphate and chloride in the waters of the Vicksburg also is noteworthy.

TABLE 120.—*Comparison of quality of water from Vicksburg formation of Georgia with that from older limestones in Ohio and Indiana.*

Mineral content in parts per million.

	Number of analyses averaged.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total dissolved solids.
A	28	20	1	40	5	10	0	140	20	5	190
B	20	20	.5	80	40	20	0	360	80	25	440
C	80	18	1.8	82	31	27	0	341	70	19	466

Percentage composition of the anhydrous residues.

D		12	1	24	3	5	40		12	3	
E		4	0	18	9	5	40		18	6	
F		4	0	20	7	7	40		17	5	

A. Average of analyses of water from the Vicksburg formation of Georgia.
B. Average of analyses of water from the "Niagara" limestone of southwestern Ohio.
C. Average of analyses of water from the limestones yielding fresh water in north-central Indiana.
D, E, and F. Percentage composition of anhydrous residues computed respectively from A, B, and C.

QUALITY IN RELATION TO GEOGRAPHIC POSITION.

Most ground waters in the belt of counties along the northwestern border of the Coastal Plain are low in mineral content and soft, carrying less than 150 parts per million of dissolved solids and less than 50 parts of hardening constituents. The waters of many deep wells along the coast in McIntosh, Glynn, and Camden counties contain 50 to 120 parts per million of sulphate and 200 to 400 parts of dissolved matter, and are proportionately much harder than supplies elsewhere, though the excessive content of chlorine that might be expected is not present. Throughout the rest of the State spring waters are not uncommonly lower in mineral content than the well waters, which range in general from 150 to 300 parts per million in total solids and from 50 to 200 parts in total hardness and commonly contain less than 20 parts per million of sulphate and less than 10 parts per million of chlorine.

RELATION OF QUALITY TO DEPTH.

It has been stated that the greater the depth of the water-bearing strata in Georgia the greater the amount of mineral matter dissolved in water from them. In some senses this is true. Many spring waters of the State contain less mineral matter than waters from wells entering deeper strata of the same formation, though whether the difference of mineral content is essentially a factor of depth or is caused by differences in the composition and texture of the water-bearing beds has not been demonstrated. It is also true that many

wells drawing chiefly from the Cretaceous at depths of 200 to 600 feet yield more strongly mineralized waters than wells entering the Cretaceous formations where they are not overlain by Eocene strata that yield strongly calcareous waters. The most reasonable explanations of this difference are that the waters of the Cretaceous in the deeper wells are mixed with waters from the overlying Eocene or that the water-bearing beds become more strongly calcareous toward the coast. Aside from these differences, however, there seems to be no basis for the belief that mineral content of water increases with depth of well in the Coastal Plain of Georgia. The deeper wells at some places yield the stronger waters, but at other places the reverse is true. For example, the water of a well 264 feet deep at Fort Gaines contains 238 parts per million of dissolved matter and has a hardness of 25 parts, and the water of another well 650 feet deep at the same place in the same formation contains 248 parts of dissolved matter and has a hardness of 23 parts. The slight difference of mineral content is insignificant. Two 710-foot wells entering the Ripley at Albany furnish supplies containing 160 and 193 parts per million of dissolved matter. Three analyses of water from different levels (all reported to be in the Vicksburg formation) in the same well in Lowndes County afford an excellent illustration of the irregular differences in mineral content; the total mineral contents of waters from the 360-foot, 460-foot, and 515-foot horizons are, respectively, 150, 138, and 149 parts; and the corresponding hardnesses are 107, 90, and 105 parts. Throughout the Coastal Plain local differences in the character and structure of the water-bearing beds or in the rate of diffusion from overlying beds cause local differences in the composition of the ground waters, but these differences conform to no general rule. As a matter of fact waters from the same depth in the same formation and in the same county may be essentially alike or noticeably different, and waters from different depths in a given formation may or may not differ in composition.

ECONOMIC VALUE OF THE WATERS.

The surface waters are lower in mineral content than most of the ground waters and consequently are better for industrial use. After the heavy loads of silt have been removed the river waters are excellent for general industrial use, being soft, usually only slightly colored, and low in scale-forming and foaming constituents. Proper filtration of them furnishes water low in mineral content, generally low in iron, soft, and otherwise satisfactory for municipal supplies.

The ground waters from Cretaceous strata are fairly low in mineral content, are usually soft, and are entirely acceptable for domestic use unless they contain too much iron.

The waters from later formations are calcium carbonate waters of moderately mineral content, rather hard, but most of them not too hard for domestic use. A number of them are low in sulphates, chlorides, and alkalies, and consequently can be softened for boiler use at relatively little expense. Preheaters would remove a great part of the scale-forming material, and none of the waters analyzed is too high in mineral content to be amenable to treatment in a cold-water softening plant. Many supplies from Tertiary rocks are reported to be "sulphurous"—that is, to contain some hydrogen sulphide—and such supplies might cause corrosion of water mains, flush tanks, and boilers. This gas, however, is readily removed or oxidized by aeration, and probably the iron in many of the waters could be similarly removed.

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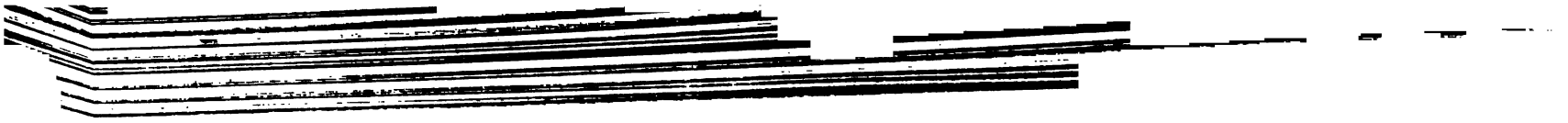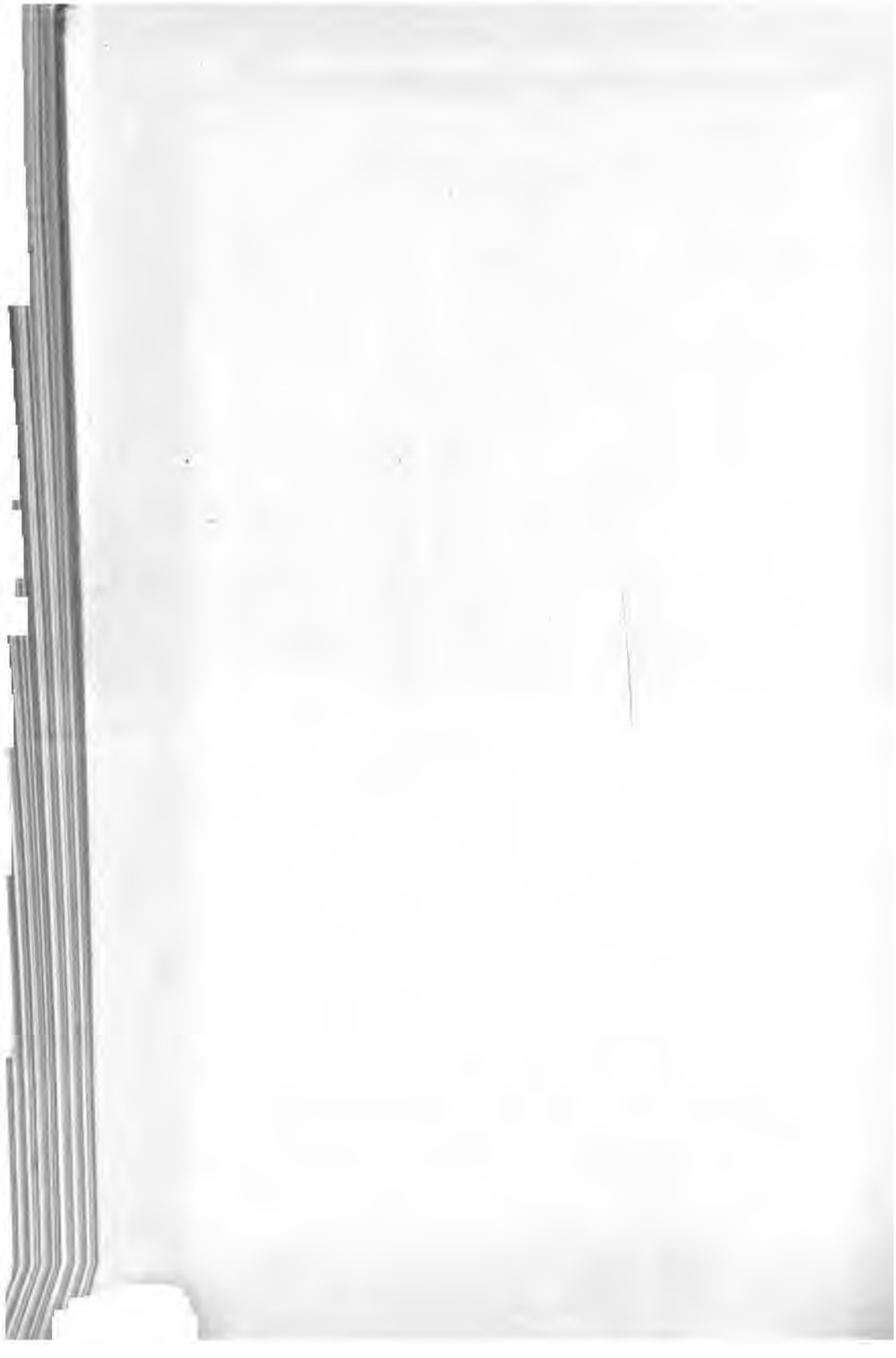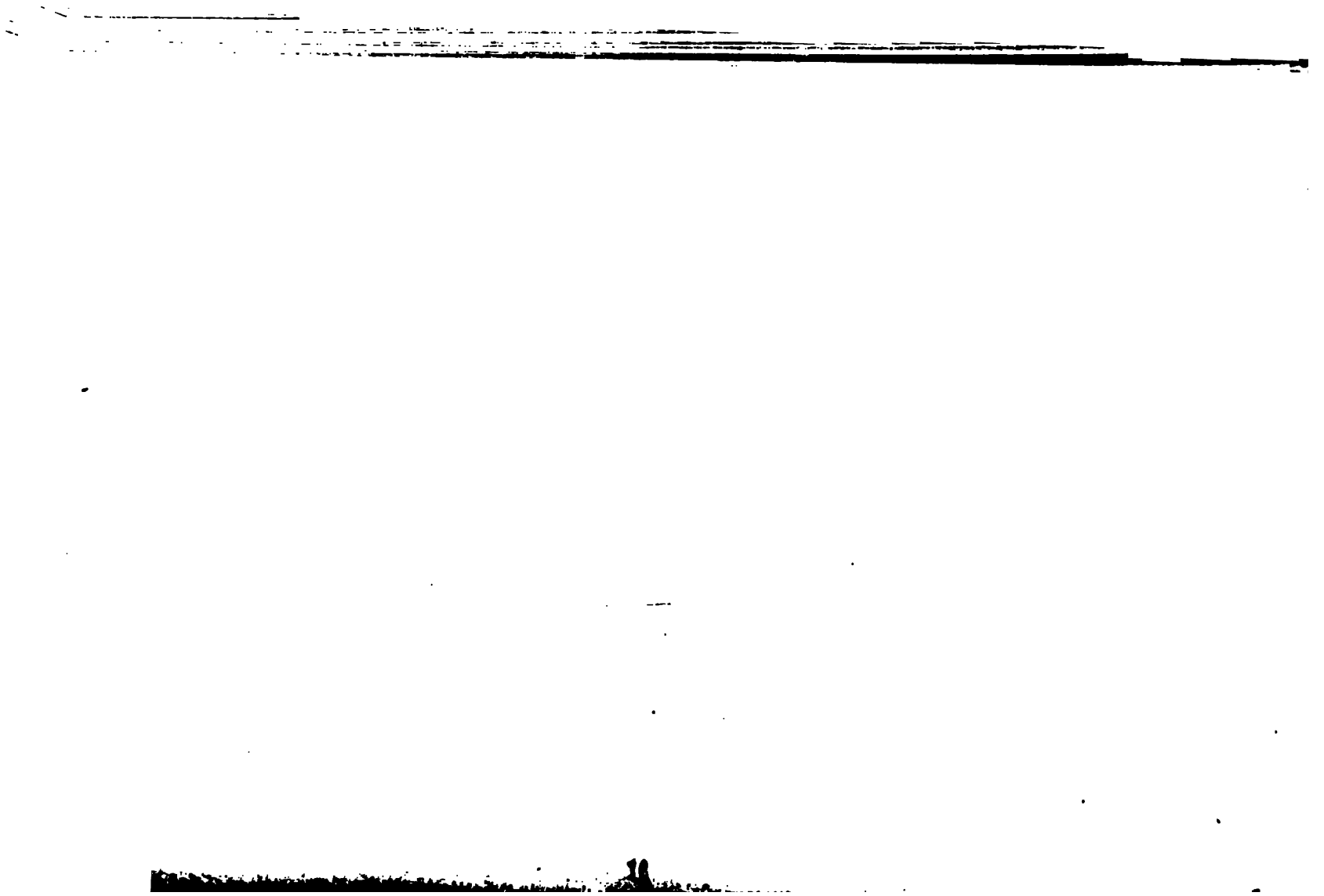
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